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THE APPLICATION OF THE ELECTRIC CURRENT TO THE EXTINCTION OF FIRE.

By A. TOLHAUSEN.

IT is a thing not generally known, that amongst the various modern applications to which the electric current has been applied, it has also found a suitable adaptation in the extinction of fires.

The agency by which this is accomplished is steam, and although the discussion of the latter with respect to its valuable properties in the extinction of fire, is not the object of this paper, still the following cursory remarks on its merits will not be out of place.

The action of steam in the quenching of flame is twofold; in the first place it prevents the access of air to the burning combustibles, and in the second place it acts as a reducer of temperature. Taking this assertion (the substantiation of which would carry us beyond our present limits) for granted, the idea to envelope, as it were, burning bodies with volumes of steam to ensure their extinction is not new, but as far as the writer of these lines is aware, the introduction of the electric current as an adjunct to steam for this purpose, is novel.

The superiority of steam over water once conceded, the next thought which must have presented itself to its supporters, was its most suitable application. In most manufacturing concerns steam is abundant, and services of steam pipes may be often found laid through the factories for warming purposes; consequently, in such cases, the interior of any such building might be easily filled with steam should a fire break out in any of its rooms, by merely allowing the steam to rush out of these warming pipes. It was further sought to render the escape of steam in fire-outbreaks, automatic, or self-acting, so as to make it entirely independent of any attention. This thought led to the application of the *electric current* in the automatic extinction of fires. The aim of this invention is to secure the steam being turned on by means of *electricity* when a given degree of heat has been attained. For this purpose, thermometers which are connected by means of wires with a galvanic battery, and an electro-magnet attached to the apparatus, are placed on the ceiling or other parts of the building to be protected against fire. In order to set the apparatus in motion, there must be an electric circuit completed, which is done in the following manner:—When a fire breaks out, the heat causes the mercury in the forementioned thermometer to rise and to come in contact with the wires leading to the battery and the electro-magnet—in other words, when the mercury rises to the point which has been fixed upon, the circuit is completed, the apparatus operates, and steam escapes into the room. When the electric circuit is completed, the electro-magnet attracts its armature, forming one arm of a lever, the other end of which holds in a notch the pin of a weighted single lever, standing almost perpendicular, and being only so much inclined as to have sufficient tendency to swivel on its centre, to fall upon a third lever depressing one of its arms and raising the other, thereby releasing a pin on the rim of the valve wheel. This being now liberated, it revolves in the direction in which it is drawn by a weight, suspended on a chain and wound upon its rim, thus opening the valve and admitting steam into the apartment through a pipe which is branched off the main steam pipe.

It is perhaps unnecessary to remark here, that although the number of thermometers may be augmented to any extent whatever, still a single battery will suffice for all; care must, however, be taken that the wires be kept apart from each other so that the electric current may at all times become established. The thermometers may be conveniently placed at a distance of from twelve to fifteen feet apart, but should a prominent place offer itself favorable to the breaking out of fire, it will be well to place an additional thermometer in such a situation.

Without entering into the constructive details of the apparatus and service pipes, the following description of two trials with this automatic fire-extinguisher will show the efficacy and surety of the apparatus. The first of these was conducted in a large room, 72 feet long by 27 feet wide. Two cart-loads of wood were deposited in this room, and after besmearing the wood with oil, it was further tarred all over. After fire had been set to this wooden pile, the doors of the room were closed, and the persons present retired to watch the effect from the outside of the room's windows. Of course the room had been fitted up for the reception of the automatic fire extinguisher, and the thermometers had been so arranged, that metallic contact should take place at 140° F. Less than two minutes elapsed between the time of ignition and the time required to raise the room's temperature to 140° F., when the steam valve opened automatically, and after three minutes and a-half longer, all flame had been extinguished.

The second trial which we propose to recapitulate took place at Halifax towards the end of last year, and in the lower Apsley Mill. The latter, a very old and greasy mill, offered uncommonly good facilities for rapid destruction by fire. It is three stories high. A large quantity of firewood and shavings were lightly stacked together in the basement storey, which is 75 ft. long, 22 ft. broad, and 14 ft. high. A committee of several gentlemen, to whom the mode in which the trial should be conducted was left, ignited the fuel in several places at the same time. The door of the mill was then closed, and the fire spread and grew rapidly; the flames licked the ceiling above, and appeared seriously to menace the safety of the building. The degree of heat was fixed at 100 degrees, which was very speedily reached. The steam was then heard rushing into the room with great force, and after a little while it first arrested and then rapidly overcame the flames. At this time there were 40 lbs. pressure of steam in the boilers. In a quarter of an hour from the lighting of the fire the door of the mill was opened, but it was found that the fire was still smouldering. Hence the doors were closed for 20 minutes longer, by which time the smouldering had been effectually overcome. An inspection of the room showed that scarcely any damage had been done, the ceiling and even the

boards on which the fire had been built disclosing very few and slight traces of fire. A second novel feature in the present trial was that, as soon as steam entered the room, an alarm bell outside the mill began to ring. This alarm bell can be easily placed in a bed room at any distance from the mill, and is so constructed that it will indicate the very room in which a fire breaks out. A buzzer may be also sounded by the machine, but as these appendages are only of secondary importance in our present object, we will conclude this article by stating some of the advantages which the application of the electric current in the extinction of fires may be said to enjoy in combination with the aforementioned apparatus. It is always ready for action, it will operate the moment it is actuated by the fire itself; it combats, therefore, in its infancy; it will act equally upon all combustibles; it does not depend on human skill or vigilance; it does not endanger life, no operators being required; it does not facilitate the access of air; it is independent of extraneous influences, such as the supply and pressure of water; it is less liable to get out of order than most other appliances; it will, at the worst, confine the fire to the room in which it breaks out, and it will, therefore, restrict the loss and inconvenience from fire and water to a *minimum*.

TRANSMITTING MUSICAL TONES BY ELECTRICITY.*

By ELISHA GRAY, of Chicago.

THIS is a method of producing musical tones of any desired pitch at any point in an electrical circuit, and consists in transmitting a series of impulses of induced electricity of high tension, corresponding in number to the number of audible vibrations constituting the said musical tone, through living tissue in contact with any resonant substance, or through a coil surrounding a bar of iron or the core of an electro-magnet, the succession of currents being produced by an induction coil or other apparatus for inducing a secondary current, and being caused by the action of any suitable circuit interrupter situated in a primary circuit.

And in order that the said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures, the same letters of reference indicating corresponding parts in all the figures.

Fig. 1 of the drawings represents one form or plan of an electrical apparatus in which these improvements are embraced; fig. 2 is a front elevation of the same, and fig. 3 is a diagram showing an arrangement of parts and circuits which may be employed in connection with these improvements.

A represents the base or frame of the apparatus; B is an induction coil of the usual form provided with the usual primary and secondary helices; C is an ordinary vibrating electrotome, which, when in action, produces a musical tone, by the vibration of its armature and circuit breaking spring a of a pitch determined by its rate of vibration, which rate is dependent upon the length, stiffness, and adjustment of the spring attached to the armature of the electrotome; C^1 is another electrotome similar to the first, with the exception that its spring a^1 is so adjusted that it produces when in action a musical tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit breaking spring a^1. Other electrotomes may be provided having their vibrating springs so constructed and adjusted that when in action the series will produce tones extending through one or more octaves. These electrotomes are situated in the primary circuit of the induction coil B, and when the said primary circuit is broken by the vibration of the circuit breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D, D^1, are telegraphic keys of the usual form

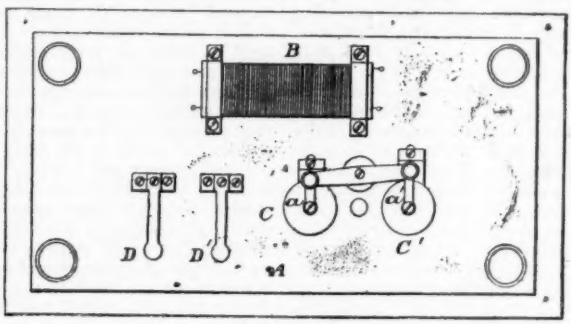


FIG. 1.

placed in the primary circuit above referred to, which circuit is divided so that it passes through both keys and both electrotomes. The keys are used for making connection with the battery.

Figs. 3 and 4 shows the arrangement of the circuits; G being the secondary circuit extending from the induction coil B to the receiving station; F, the battery; and H, the primary circuit from the battery through the keys; D, D^1, magnets of the electrotomes C, C^1, and the primary circuit of the induction coil B. E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows:—On depressing either of the keys D, D^1,

* Taken from the Specification.

the primary circuit from the battery F will be closed through one of the electrotomes, and the spring or circuit interrupter of the latter will immediately commence to vibrate, producing a musical tone of a certain pitch dependent as before stated on the size and adjustment of the spring, and interrupting the primary circuit of the induction coil B. These interruptions will induce secondary currents in the secondary circuit of the

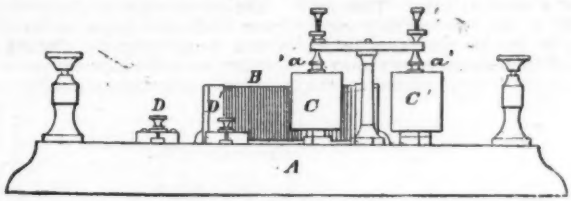


FIG. 2.

said coil, which will correspond in number with the vibrations of the circuit interrupted, and the number of musical audible vibrations constituting the tone produced. Thus, for example, if the circuit interrupting spring vibrates one hundred and twenty-eight times per second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal

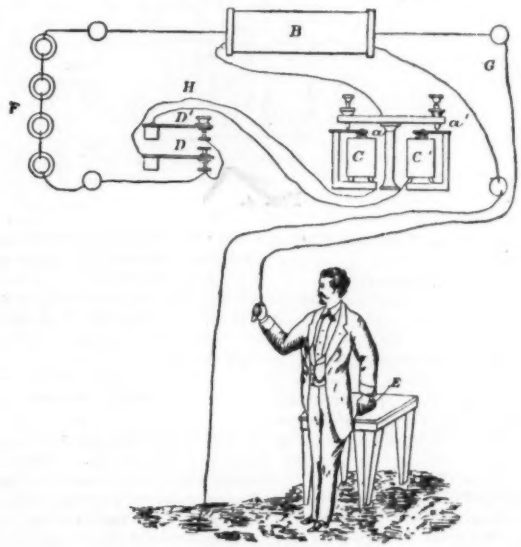


FIG. 3.

induced currents will be generated in the secondary circuit.

If now a person places himself in the said secondary circuit and brings his hand or any other part of his body in contact with any resonant substance which is a conductor of electricity, so that the circuit is completed through it, the said resonant substance being either the metallic cylinder shown at E, or a plate of metal stretched above the body of a violin by metallic strings, or a sheet of foil paper stretched over a metallic ring, or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator will, from some cause not yet fully understood, produce a corresponding number of vibrations in said resonant substance, and a musical tone will be given forth of a quality dependent upon the character of the resonant substance, but of the same pitch as that produced by the vibration of the circuit interrupter at the transmitting end.

Instead of interrupting the primary circuit by vibrating automatic electrotomes, and thereby inducing the secondary current of high tension which is transmitted to the resonant receiver, the necessary interruptions for this purpose may be effected by any mechanical device which will produce a sufficient number of interruptions per second to cause a musical tone.

The secondary coil may be dispensed with and the secondary currents induced in the primary coil, when the primary circuit is interrupted, may be transmitted to the receiver for the purpose of producing the audible vibrations.

Another form of the apparatus is constructed as

follows:—The transmission of sound is effected as in the apparatus above described by the conversion of electrical impulses of high tension through a secondary circuit into audible vibrations, but the apparatus is based upon the principle that an electrical current traversing a coil surrounding a bar of iron or the coil of an electro-magnet, causes a slight elongation of the said bar or core, which elongations, if they succeed each other with sufficient rapidity, will result in a vibration of the bar, and the production of a musical tone. This apparatus is shown at fig 4, the transmitting apparatus being the same as in the apparatus before described, but the receiving apparatus as shown at E, consists of an electro-magnet placed in the

The amount of current which is necessary to produce the effect is almost unappreciable. Less than one-hundredth part of the battery power now required enables audible signals to be transmitted over long lines. The apparatus can therefore be employed with advantage on submarine lines, and the rate of transmission over them can be thereby much increased.

As a telegraph apparatus it is simple, economical, and rapid in its operation.

The apparatus may also be employed to transmit tunes from one place to another; the vibrating pieces being properly pitched and sufficient in number, even the different parts of a musical composition each simultaneously played in different

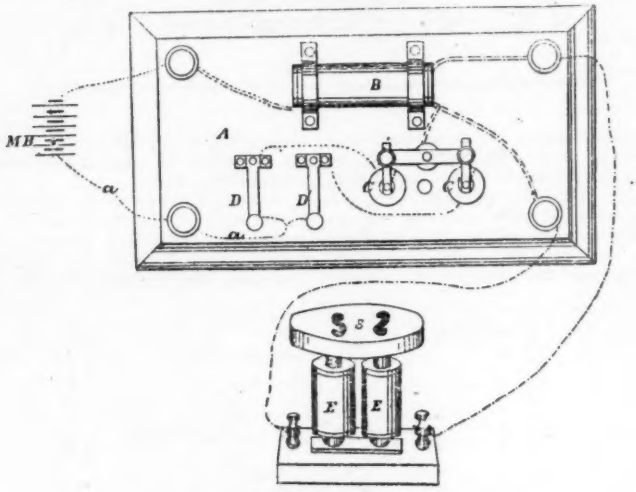


FIG. 4.

secondary circuit; S represents a hollow cylinder of metal which is placed upon the poles of the electro-magnet and intensifies the sound.

The uses to which the apparatus may be applied are various. In telegraphing for example, instead of transmitting messages by means of the Morse alphabet now in general use, tones of different pitch corresponding to the letters may be employed, which tones can be produced more rapidly than printed or impressed dashes can be made, and their duration would be shorter than the intermissions now required for producing dashes and dots in succession.

A very slight interval would be necessary between the tones to indicate the separation, and as dashes would be indicated by one tone, and dots by another, all signals would have the same length. Instead of using one tone for dashes and another for dots, signals could be devised consisting of tones of various combinations. These signals can soon be readily learned and read by any operator capable of distinguishing tones of different pitch, who by placing his ear in contact with the resonant substance, would cause the tones to be produced, and still have both hands free to receive the message. By means of a type writer an operator could record about eighty words a minute.

places may be transmitted to the same place, so that the whole will be there audible. In the latter case a separate circuit and transmitting and receiving apparatus will be required for each part of the musical composition, and it will be necessary to beat time by telegraph for each set of performances.

THE WORD TARIFF.

THE Eastern Telegraph Company have given notice that the *word* tariff and the new rules and regulations based on the recent International Telegraph Convention held at St. Petersburg, will come into operation on January 1st, 1876. The price of a message to Egypt becomes 1s. 7d., to India 4s. 6d., and to China 8s. 4d. per word, the sender having to pay for every word in the message. The Company will register free of charge the names and addresses of firms receiving messages, so that the number of words in the addresses shall be reduced to a *minimum*. In fact, two words, "Hercules, London," are all that is required. Nor need the name of the sender of a message be transmitted, for the last word of the message can be made to represent the sender. Thus the bugbear of long addresses is entirely swept away.

The *maximum* length of a word in European messages is fixed at 15 letters, and for extra-European messages at 10 letters. Each group of five figures will be counted as a word, the excess over five being an additional word. Every separate character, whether a figure or a letter, or even an underline will be counted as a word. Signs of punctuation, hyphens, apostrophes, inverted commas, will not be regarded or signalled. A few abbreviations will, however, be accepted as one word. These are—

R.P. (Response payée)—answer prepaid.

T.C. (Telegramme collationné)—repeated message.

C.R. (Accusé de reception)—acknowledgment of receipt.

P.P. (Poste payée)—postage prepaid.

X.P. (Exprès payée)—express prepaid.

Accuracy in transmission can be ensured by the sender having his message repeated back, and he can have this done on payment of half the usual rate additional. The repetition of all messages written in secret figures or letters is made compulsory, while figures will only be accepted in code messages, or messages not in plain language, on the senders declaring that they have no secret meaning. Messages composed of secret letters will not be taken at all except from the Government.

The sender of a message can learn whether it has been duly and properly delivered, and at what hour and date, by paying for a message of 10 words, and inserting immediately after the address the words, "acknowledgment paid," or its abbreviation, "C.R."

Replies can be prepaid, but they will be restricted to three times the number of words contained in the original message. On the Continent messages can be sent so as to follow a receiver, if he has left the first address, on his paying for the second message on its delivery. For instance, a message may be addressed "John Smith, Bernerhof Berne, or Sweitzerhof, Zurich, à faire Suivre."

Many other minor rules, respecting modes of payment, reimbursement and multiple messages, will come into force, but we have indicated generally the principal changes, which must have a very serious effect upon that business which is called "packing."

BLOCK SIGNALLING.

(Continued from page 248.)

With all the foregoing forms of signal instruments electro-mechanical bells were employed, that is, bells rung by mechanism, the mechanism being put in motion or released by the electric current. These bells were used principally as alarums to call attention, and were scarcely fitted for any other purpose. To be in good order they must be kept wound up and well adjusted. The former operation had to be performed by the signalman, and was not unfrequently forgotten. The latter required the attention of the Inspector or Lineman with every marked alteration of the power of the current whether caused by leakage on the line wire or by reduced battery power.

The first bell really adapted to railway signalling purposes, or for any signalling purposes, where a code of signals was required to express different meanings, was introduced by Mr. C. V. Walker, F.R.S., on the South Eastern Railway in 1852. It is worthy of remark that the same description of bell is still in use. Its construction is as simple as possible, being merely a pair of electro-magnetic coils wound with large (No. 16 and No. 18) copper wire insulated with cotton, and an armature placed in front of the poles of the electro-magnet, carrying the hammer required to strike the bell. A great feature to be noticed in the formation of this instrument is the size of the wire. Up to the date of its introduction no such gauge wire had been used for telegraphic apparatus. That its inventor thoroughly understood his subject is shown by the satisfactory result obtained. It is now generally understood that to obtain the maximum effect on any instrument its resistance should as nearly as possible equal the resistance of the line and battery. The battery, which Mr. Walker employed with his bells, and which was also a new invention at the time, was the graphite battery, a battery of large quantitative power and little internal resistance, hence the success attending the use of the large wire for the coils of the bells.

Successful, however, as was, no doubt, the introduction of this instrument—for it was speedily adopted and applied on the South Eastern line—it scarcely comes within the term of a block signal instrument. That it was for many years used as such on the line mentioned, and used with great success, is a fact beyond dispute, and as such speaks volumes in praise of those in whose hands it was placed for the regulation of the traffic. The railway traffic of those days was not, however, the railway traffic of the present date, and it may be safely assumed that railway managers of to-day would hesitate before adopting for the protection and regulation of the increased and increasing traffic of the present period an instrument which gave no indication of the signal conveyed beyond that of the sound of the bell. If proof of this were wanting, it may be found in the fact that of late years Mr. Walker himself has applied such an indication to his system. That the necessity for it it was felt by the signalmen themselves, was shown by Mr. R. S. Culley, now the Engineer-in-Chief of the British Postal Telegraph system, during the discussion on a paper on "Railway Telegraphs" by Mr. W. H. Preece, read before the Institution of Civil Engineers in 1867.

Having referred to his long experience in the management and maintenance of telegraphs and systems of train signalling, in Scotland, and on almost all the lines of railway in the West, the Midland Counties, and the North-West of England, he proceeds to remark:—"He had found the system "of permanent signals preferred to those in which "the same wires were used for both lines of rails, and "by which trains were simply reported as *in* or *out* "of a tunnel. It was true that the want of a per-"manent visible signal was in some measure com-"pensated for by the entry of each signal in books "provided for that purpose; but, unless the entry "was made at the moment, there was danger that "it might be neglected and the book be made up "afterwards. At Springwood, near Huddersfield, "there were two tunnels, connected by a short, "open cutting, in which cutting was a junction

"with another line—a most difficult point to work. "There were three cabins with telegraphs. So "much were the men impressed with the necessity "of having a permanent signal, that they invented "one of their own, consisting of a piece of red rag, "placed on the instrument when there was a train "in the tunnel, and removed when it was reported "clear."

Fully alive to this, we find Mr. Tyer entering the field in the same year as that in which Mr. Walker produced his bell, with an arrangement which, although having its disadvantages, yet possessed many advantages over the form of instruments then in use for railway block signalling. Hitherto train signalling instruments had been the adaptation of the speaking telegragh instrument or merely by bell. In the former the signals were sometimes transitory, sometimes permanent, but the instrument was available at any time for conversationa voted to the "clear" signal. Care was requisite in manipulating these keys or plungers so that the wrong one might not be pressed, and thus a wrong signal sent—as *blocked* for *clear*. In Mr. Tyer's later form of instrument this difficulty has been greatly, if not entirely obviated. Of the two pointers referred to above, the upper one was the *block* signal, by which the up traffic was governed, the lower merely the indicator worked by the outgoing current , showing the signalman the last signal sent by him to the adjoining signal station for the control of down train. Although not strictly reliable as such, being worked by the outgoing current, yet, when all was right it formed a truthful repetition of the signal last sent to the distant box, and as such was of great value to the signalman. The upper or block indicator could only be altered by the signalman at the distant box n the direction of which the train was proceeding; the signalman at any

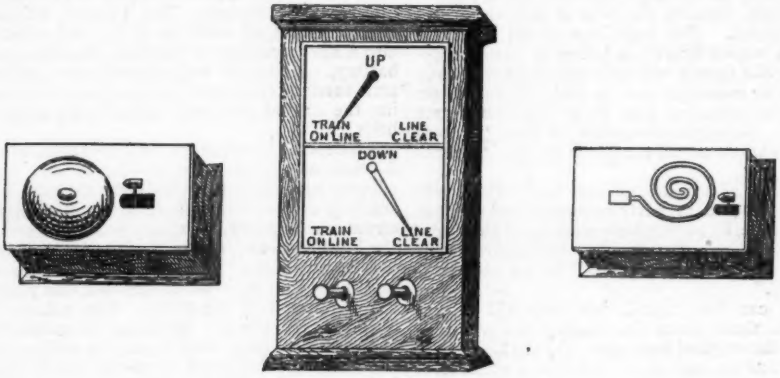


FIG. 6.

purposes. The bell was free from this latter objection, but its signals were also transitory, and dependable entirely upon the sense of hearing or sound. Mr. Tyer aimed to secure for his arrangement that which recommended itself in both of these systems—a permanent signal, and a permanent record of that signal so long as it should be required, whether to indicate train on line or line clear; combined with a single stroke bell on which any number of clear and distinct beats might be given.

Figure 6 represents the earlier arrangement employed by Mr. Tyer. It consisted of an indicating or block instrument, a bell, and a gong. Up train signals were sounded on the bell, down trains on the gong. The face of the indicating instrument was divided into two portions, each of which was provided with a pointer or indicator having two movements—to the right and left. The upper portion was devoted to up trains, the lower to down trains. Below the indicators, two keys, termed plungers, were arranged so that pressing either of them inwards brought the battery in circuit with the wire, and so transmitted a signal to the corresponding signal station. On the key resuming its position of rest, the line was placed in circuit with its respective indicator. Whilst one key was employed for the "block" signal, the other was de- one station had thus no control over the block signal governing trains at his station and in this lies the chief of the improvements effected by Mr. Tyer.

ON A SYSTEM OF TELEGRAPHY.

A COURSE OF LECTURES, DELIVERED AT THE SCHOOL OF MILITARY ENGINEERING, CHATHAM.

By W. H. PREECE, Member Inst. C.E., &c.

LECTURE III.—COMMERCIAL TELEGRAPHY—PART II.

(Continued from page 244.)

HAVING in my last lecture sketched the growth and present state of the plant of the system of commercial telegraphy in England, and the character of the operators engaged in its working, I purpose now to examine the internal organization, established for the maintenance of the wires and apparatus, and for the transmission of messages.

We must assume the system constructed and in full operation. We will also assume the whole system under the united control of one administration. There must necessarily be two branches:—the one engaged in securing the upkeep of the wires and the working order of the apparatus, the

other engaged in the manipulation of the instruments and the distribution and disposal of the messages. The first is called the *Engineering*, the second the *Commercial* branch.

1. *Engineering Branch.*—The unit of this system is *the lineman's length*. The unit varies with the character of the telegraph and the number of offices within the sphere of action. On a heavy trunk road line like that proceeding from New Cross through Tunbridge to Beachy Head, one man is appointed to about 25 miles of line. On a lighter line one man is appointed to from 30 to 40 miles of line. On a railway, one man can take from 80 to 120 miles of line. These lengths would be decreased with the number of instruments under his charge. The average length is about 25 miles of trunk road, 25 miles of branch lines, and 15 offices, averaging 25 instruments.

The lineman's duty is to patrol his line periodically to see that no defects exist, and to remedy any that appear. To maintain the poles firm and intact, the stays and struts in order, the insulators whole and sound and tightly screwed up, and the wires properly jointed, regulated, and clear of trees. He must visit each station under his charge periodically, to clean, oil, and examine his instruments, to clean and refresh his batteries and keep them in working order, to pay especial attention to the condition of the leading-in wires, and to maintain the earth connections sound. The regulations are that he visits each head-office once a month; each sub-office, if a needle station, once in every two months; if an A B C station, once in every three months. Every lineman has a depôt in which he retains a small stock of tools, instruments and stores, which experience has shown necessary for maintenance purposes.

Over every four or five linemen, according to the geographical character of the country and the direction of the lines, an *Inspector* is placed, who resides in some central spot, and whose territory is called a *section*. It is his function to see that the linemen carry out their duties, and for that purpose to periodically inspect their lengths *on foot*. Experience has shown that the inspection of telegraphs in any other way than on foot is a myth, for the rapid view taken in a trap or in a coach allows defects to be passed which speedily ripen into serious faults. Faults will arise spite of all forethought and care on the best organised lines. Wet weather opens out wounds that are imperceptible in dry times. The position of a pole may be disturbed by a hundred different adventitious circumstances, and the wires upon it thrown out of regulation and brought into contact. Lightning and storms of wind may bring down branches and trees upon the wires, and many accidents arise from falling boulders and rocks; overladen wagons may bring the wires together at crossings unless they are maintained at proper heights and in proper regulation. Passers-by amuse themselves by lashing at the wires with their whips, and not unfrequently find to their chagrin that a portion has been left behind upon the wires. Boys take an exceeding delight in flying their kites in proximity to the wires, and lose their tails as well as their kites. Engine drivers frequently throw away their waste, which the wind in its wantonness deposits upon the wires. Various moving accidents by flood and field tend to disturb the wires, and it is only the watchful surveillance of the inspector which prevents their rapid conversion into serious breaks down.

Telegraphs can only be maintained in working order by incessant, constant, and personal inspection, and the efficiency of a well-constructed telegraph—its freedom from faults—is the measure of its supervision.

There are three general kinds of faults experienced on telegraphic circuits, which are subdivided into three species.

1 *Disconnections*, which are indicated by the total or partial cessation of the current. These are further divided into—

(*a*) *Total disconnection*, such as that produced by a wire broken within its insulating covering, an open switch in an office, a fused wire in a coil, a wire off its terminals, &c.

(*b*) *Partial disconnection*, such as that produced by an unsoldered joint, a dirty contact, improperly applied lacquer, a loose terminal, a bad earth, &c.

(*c*) *Intermittent disconnections*, the results of a bad joint which moved by the wind, by passing objects, or by heat, makes and breaks contact at irregular periods.

2. *Earths*, which are indicated by the increase of the current at one end and its decrease or cessation at the other end. They are also subdivided into—

(*a*) *Dead earth*, such as that produced by the broken end of a cable in the sea, or of a wire resting on the damp ground, a wire resting on a stay or earth wire, a lightning protector with its two plates fused together, &c.

(*b*) *Partial earth*, such as that produced by cracked or defective insulators, by wires resting upon walls, posts, trees, &c., bad guttapercha wire, &c.

(*c*) *Intermittent earth*, such as that produced by the wire expanding under heat or moved by the wind, and touching some body in contact with earth.

3. *Contacts*, which are indicated by the currents from one circuit passing into another circuit, and are subdivided into—

(*a*) *Metallic contact*, such as that produced when wires are twisted together, hooked together at joints or joined together by other pieces of wire.

(*b*) *Partial contact*, such as that produced by bodies of high resistance—wet kite strings or whipcords for instance—connecting the two wires together, bad earths, and wet weather on badly insulated and unearth-wired lines.

(*c*) *Intermittent contacts*, such as those produced by the clashing together of imperfectly regulated wires in storms, in the hands of careless workmen, or by the flocks of birds which sometimes rest upon the wires; and frequently by loose pieces of wire carelessly thrown upon the wires, and adhering to one of them whilst they are blown occasionally against the other.

The whole system of engineering organization is directed first to the prevention of these faults and secondly to their rapid removal should they unfortunately occur. It is, therefore, essential that the inspector have a thorough and constant knowledge of the condition of the lines, wires, and instruments under his charge. This he obtains not only by incessant personal inspection, but by daily and periodical electrical tests of the most search-

ing character. The inspector's section is so arranged that he can regularly and fully carry out these duties.

Every two or three sections are grouped into a *subdivision* over which is placed a *Superintendent*, whose duties are as much of a clerical as of a spectative character. He sees that all the rules and regulations of the service are fully carried out, he is paymaster and adjutant, he keeps all stock accounts, pays all the men, carries out works orders, supervises the inspectors, maintains a general inspection over the whole of his subdivision, and keeps a watchful eye over the condition of the circuits under his charge.

It thus appears that the supervision of a superintendent as well as that of an inspector is of two kinds—the one *active*, the other *passive*. The active supervision consists in close personal inspection of all work done, and of the actual visible condition of the plant. The passive supervision consists in the careful examination of the electrical conditions of the circuits under his charge. The electrical tests applied to the wires are daily and periodical.

The daily tests are of two kinds :—

(*a*) Those applied to sub-office circuits.

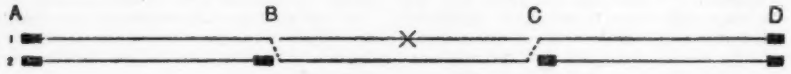
(*b*) Those applied to head office circuits.

(*a*) These are simple. Every sub-office, when the recognized operator comes on duty, is called by his head office. He watches the character of the signals he receives, whether they are of the usual strength or weaker than usual, whether they are readable or unreadable. If they are readable he replies "signals good" or "signals weak" as the case may be. If they are unreadable, or if the station's attention cannot be called, the head office knows that there is a fault on. If all circuits are good he reports to the inspector "all circuits right." If one circuit is broken down he reports "broken down to A, all other circuits right." The inspector in the latter event at once directs the lineman to go after the fault and to repair it as rapidly as possible.

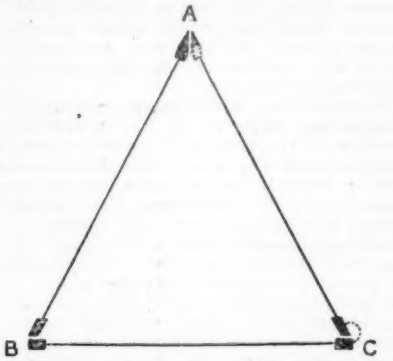
(*b*). Every head office circuit is examined every morning between 7.30 and 7.45 by a tangent galvanometer. It is an operation like that of looking at the tongue and examining the pulse of a patient. The circuits are divided into convenient sections and tested by a recognised and experienced testing clerk. A given electromotive force is applied to each wire which is disconnected at the distant end, and the current passing into the circuit is noted by recording the reading of the tangent galvanometer, and knowing the constants of this instrument, by a simple calculation, the condition of each wire is known.

At offices where there are many wires the tests have to be taken very rapidly, hence they are rough, but they are ample for the purpose and fully efficient. The great object is to obtain the earliest possible information of the condition of the circuits so as to be able to send off the line-man at once after faults, to remove them before the busy hours of the day commence.

Supposing that the wire when tested gives indication of the existence of such a fault as to interrupt the communication.—What is done?—The circuit if it is an important one, is made good by crossing with some other less important wire. The value of the importance of a wire as a rule is the number of messages it carries, but it may also serve some distant station which has no alternative route. Thus if a fault be on No. 1 wire between B and C, and the circuit between A and D be one of not much importance, then both wires at B and C are disconnected. The up portion of No. 1 wire between A and B is connected to that portion of No. 2 between B and C,

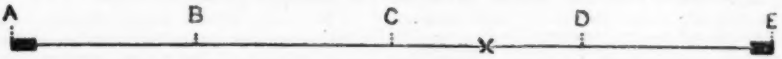


which is again connected to the down portion o No. 1, thereby making No. 1 good throughout. Or there may be another outlet thus :—Suppose the circuit A B be broken down, a mere cross connection at C restores the communication between A and B.



In any case when the existence of a fault is proved, its positlon is localized, and instructions are issued for its removal.

Practically on overground wires, faults are simply localized by disconnecting or by putting the wire to earth at successive stations until it is localized between two stations. At certain stations the wires are led into testing boxes where the wires are attached to terminals which give facilities for



crossing, disconnection, and putting to earth.

First, the wire A E is to earth somewhere between A and E, A is the testing station. A first directs B to disconnect for one minute; he does so, the wire proves good; at the expiration of the minute he joins up again and C is directed to do the same;

he does so, and the wire again proves good. D then disconnects, and the wire proves bad, hence the wire is faulty between C and D. Secondly, the wire may be disconnected at the same place; the same operation proceeds, excepting that B C and D put the wire to earth in place of disconnecting it.

(To be Continued.)

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY.

(Continued from page 247)

Pole Fittings.

Arms and Brackets.—In this country wooden arms have been more largely used than any other means of attachment between the insulators and the poles. They possess several undoubted advantages over other methods of fastening, being more solid and secure, and improving the insulation of the wires, by offering a very perceptible resistance to leakages from the insulators. These arms should be cut out of the best English spine oak, and the dimensions generally adopted in England, after many years experience, are 24 and 33 inches long, by 2½ inches square. When shorter than this, the wires they carry are liable to interruptions through contact, and if the transverse strength is diminished, they are apt to be broken off, or the ends split, when a wire breaks. Further, it has been found that in automatic high speed working, induction from wire to wire interferes materially with the rate of speed that can be obtained. By diminishing the length of the arms, this effect is materially increased. Each arm should be bored with three holes, two vertical, at 3 inches from each end, ¾ inch in diameter, to take the insulator bolts, and one in the centre, horizontal, ⅞ inch diameter, for the pole bolt. Arms of this size, when properly selected, will serve all ordinary purposes, possess sufficient strength as intermediate supports, and will even hold wires when terminated on them transversely. They should be fitted with earth wires of No. 16 gauge, each wire taking two turns around the arm close to the pole. These wires should be only fitted after the arm is dry and has been painted, and no paint should ever be allowed to cover their surface.

Galvanized iron bolts, usually half-an-inch in diameter, and of varying lengths, are employed for attaching the arms to the poles. Some use bolts of heavier metal, but the former afford ample strength for the strains to which they are exposed. Each bolt should be provided with two washers, one 3 inches by 2 inches by ¼ inch, the other 2 inches by 2 inches by ⅛ inch.

Brackets of wrought, cast, and malleable cast iron, of various shapes and sizes have been used. That most commonly adopted in this country is made of malleable cast iron, and consists of a hollow shank, four inches long, at one extremity of which is a convenient receptacle for the insulator bolt, the other extremity being provided with a kind of foot, pierced with three holes, which admits of its being fastened to the pole by nails or screws. Three-inch galvanized clout nails are ordinarily employed, though coach screws of a like length are sometimes used. They afford a better hold, but one difficulty with them is to get the men to treat them fairly. They generally drive them in instead of screwing them, and in such cases a nail had better have been used.

A modification, termed a bridge bracket, is adapted for driving into walls, bridges, and masonry generally.

Pole Roofs.—The primary object of a pole roof is to prevent the moisture and wet from entering the interior of the pole at the top, where a transverse section of all the pores of the timber is exposed. Roofs of many kinds have been imagined and used, from a circular disc of flat iron surmounted with a lightning protector, to elaborate turned or moulded tops where ornament is an object. Earthenware roofs have been very largely used, but all these have been almost wholly replaced by a single sheet of galvanized iron bent at right angles in the centre, and nailed to the top of the pole, the latter being cut to fit it. This effectually throws off the wet, and likewise affords a convenient position for a wire which is supported by a special bracket termed, technically, a saddle. Poles placed in or near towns are generally fitted with something more pretentious, and the engineer herein indulges his own fancy in designing a suitable ornament.

Stays generally are formed of wire stranded together, either by hand on the spot or by machinery. They are usually attached to stay rods at the ground line. These consist of galvanized iron rods varying from five to eight feet long, and from half to three-quarters of an inch in diameter. The most approved form have a square head wrought at one extremity, and an arrangement for tightening the stay at the other. This consists of a loop or shackle which fits on the top of the rod, and is held in any desired position by an ordinary nut on the latter. In exceptional cases continuous iron rods are employed. This will be fully dealt with later.

Stays are anchored in the ground by means of stay blocks, which are usually lengths of timber two to three feet long, and which may consist of any description of wood which is conveniently available. Where new timber is used, the most crooked, or that least adapted for use as poles, is selected and cut up, but it frequently happens that a large and useful supply of blocks can be obtained from old timber recovered during the renewals of other lines. If the poles have been dug out, the butts, especially when planted in clay or heavy soil, below the rotten portion form the best timber that could be used, being hard and well-seasoned.

The soundest and hardest of the upper portions of the old poles can, however, be used with advantage, especially if they are immersed in creosote. This can be effected at slight expense. A ship's water-tank is obtained, mounted on bricks so as to admit of a fire being lighted under it; it is partially filled with creosote, and the blocks immersed. The useless portions of the wood form the fuel, and at any depôt a large number of blocks can thus be prepared in a very short time, and at very little cost beyond that of the creosote.

If very dry timber, such as that referred to above, were used without previous preparation, it would be liable to rot very quickly when buried.

Elm and beech, when green, serve excellently as stay blocks. for when buried in that state they last for an indefinite period. Outer slabs or tem-

porary sleepers of this material can occasionally be obtained very cheaply at saw mills where this timber is cut up.

MATERIALS FOR UNDERGROUND TELEGRAPHS.

Copper, on account of its high conductivity, is the metal used for the conductor in all underground work. Various insulating media have been suggested and experimented with, but guttapercha and indiarubber alone have to any considerable extent been employed, and the former is that almost exclusively used in England.

Under proper treatment, and in favourable circumstances, the durability of guttapercha is very great, but when exposed to light and air it deteriorates very rapidly through oxidation, losing its elasticity, assuming a resin-like form, cracking throughout, and its insulating powers becoming rapidly less and less. When, however, protected from the admission of light and immersed in water there is, if the material be of good manufacture, scarcely a known limit to its life, as under such circumstances it appears practically indestructible.

In the manufacture of guttapercha, the crude material is first subjected to various processes by which the impurities mixed with it, in collection or transit, are eliminated. It is then partially liquified or rather much softened by heat, and applied to the conductor by being forced through a die. To diminish the possibility of defects in the covering, it is generally laid on in separate coatings, the minimum being two of guttapercha and two of a material termed Chatterton's compound, a composition of guttapercha, resin, and Stockholm tar. This composition effects a perfect union between the various coatings of guttapercha, and between these and the conductor.

Ordinary copper wire has a tensile strength of 60,000 lbs. per square inch, but that used for telegraphic purposes, being selected more with a view to its electrical than its mechanical qualities, varies from 35,000 lbs. to 39,000 lbs. only. Guttapercha has a tensile strength of about 3,500 lbs. per square inch, but owing to its great extensibility, it does not add more than one-third its whole strength to the complete wire. It begins to elongate with a strain of about 6 cwt. per square inch.

Jenkin gives (Cantor lectures) the following approximate formulæ for the mechanical strength of copper wire :—

"A copper strand will bear 1½ lbs. per pound weight per knot before breaking. It will stretch 1 per cent. with 1 lb., and will not stretch at all with 0·75 lbs. weight per pound per knot."

Extending this to the guttapercha, on the basis of the figures quoted above, it would appear that the latter adds a little over half a pound additional useful strength for each pound weight of guttapercha, and that it will commence elongating with rather less than a quarter pound for each pound weight of material per nautical mile. These considerations are of value in dealing with underground work, which is frequently exposed to considerable strains, under the method of laying it which obtains in this ountry.

Formerly, in England, a conductor of No. 16 B. W. gauge, covered with guttapercha to a thickness indicated by Nos. 3 or 4 B. W. G., was in general use for underground telegraphs. For some past years, however, the improvement in the conductivity of copper used for telegraphic purposes, and the success with which the endeavours to increase the insulating properties of guttapercha have been crowned, have enabled manufacturers to issue a wire, having the same electrical qualities, and occupying much less space. Thus a conductor with a gauge of No. 18, covered to No. 7 B. W. G. with guttapercha, is equal electrically to the wire formerly in use, although containing but half the weight of the insulating material, with the further advantage that a much larger number of wires can be drawn through a given size pipe or conduit. On the other hand, it should be noted that the mechanical qualities are diminished by the decrease in size, both the strength of the wire being less, and the insulating coating being more readily damaged, by any cause which might have been insufficient to bare the conductor with a thicker coating. In specifications for G. P. wire, the gauges of the conductor and insulator respectively should be clearly laid down, in decimals of an inch, together with the conductivity of the copper in terms of pure metal. The latter is generally taken at 100, and inasmuch as some specimens of copper have a conductivity of 27 only, as compared with this standard, it is evident how necessary it is to agree on a minimum result. Some cable wires have as high a conductivity as 96·8 per cent., but for underground work 90 to 92 may be taken as a minimum. The wire should be carefully tested in water, and a minimum insulation of 200 to 250 megohms per mile, at a temperature of 75 degrees Farenheit, should be stipulated for in the case of wire of the dimensions referred to above. The wire before use should be covered with a layer of tape, saturated with Stockholm tar, and wound on spirally, to protect the guttapercha. Stockholm tar is not an insulator, in fact it is well known that it diminishes the insulating capacity of the guttapercha to which it is applied, but it more than counterbalances this, in protecting the gum from the injurious effects of the atmosphere, from which it would otherwise suffer.

To protect the insulated wire grooved boarding was at one period extensively used, either plain or creosoted, in some cases with separate grooves for each wire, and sometimes with one large groove for several wires. Except for leading wires into and through buildings and tunnels, this form of protection has been abandoned, and in the latter cases it is now generally constructed in the form of a rectangular box, of the size necessary to carry any given number of wires thought neceesary. Ordinary Baltic or pitch pine boarding is planed, cut to size, three of the sides of the rectangular box are nailed together, the fourth or lid being either screwed down or attached by means of a wire; or a rectangular trough may be ploughed out of a solid piece of quartering by means of suitable machinery. This is perhaps preferable when the boxing is not intended for many wires, as in this case a circular or other agreeable moulded form can be readily given to the outer portion of the case.

Creosoted timber should not be used, as creosote affects the G.P. injuriously, neither should coal tar be allowed to come in contact with the latter for a like reason. If coal tar be used for preserving the casing it should only be applied outwardly. For underground work, pipes either iron or earthen-

ware, are now used, the former being invariably employed fn towns, the latter frequently in the country. Formerly iron pipes, slit throughout longitudinally, the upper portion forming a lid, were much employed, the lower half being laid in an open trench, and the cover placed on after the cables had been laid into it, but in this country ordinary gas or water-pipes have entirely superseded the split form, in consequence of the impossibility of withdrawing cables from the latter for repairs, &c., without reopening the ground throughout. The iron pipes now used for main lines are generally three inches in diameter, of a good quality of cast-iron, each measuring nine feet, provided with a socket, and weighing about 100 lbs. The pipes should be cleanly cast, and free from jagged edges and other imperfections in the interior, which would tend to injure the insulating covering of the wire. For light lines pipes of a lesser diameter, either of cast or wrought-iron, can be used.

Where mechanical injury is not anticipated, such as in country roads, earthenware pipes are very effective, and much cheaper than iron ones. These are usually two and a half to three feet long and provided with a socket. They should be straight, clean, free from irregularities, and well burnt and glazed.

Test boxes, placed at regular intervals for convenience of drawing in the cables, testing, &c., are generally of two forms. In towns where the pipes are laid under the paved footway, rectangular iron boxes, with covers formed of a flagstone to correspond with the paved way, are employed, the top of the box being level with the footpath. Two sizes are generally used, according to the number of wires in the pipes, one being 28 inches long by 9¾ inches wide, with a depth of 12 inches, and the other 32 inches long by 13 inches wide.

Where the pipes are under the cartway, the boxes are kept below the level of the metalled road, and an iron cover is used in lieu of the stone one. Sufficient strength should be given to this cover, and it should be placed at an adequate depth to resist the crushing effect of steam road-rollers in towns where these are used.

(To be Continued.)

Notes.

We understand that the Submarine Company's cable, between Dover and Calais, is interrupted.

The Indian Government has announced its intention of joining the International Postal Union

A telegraph cable is to be laid between the Admiral's Office at Queenstown, and the yard and hospital at Haulbowline.

The Great Northern Telegraph Company announce that communication is restored through their China and Japan cable.

The traffic receipts of the Direct Spanish Telegraph Company for the month of November, 1875, were £1,697 16s. 10d., against £1,224 10s. in the corresponding period of last year.

The average time occupied in the transmission of telegrams between Madrid and England, "viâ Santander," during November, was 2 hours 25 minutes (including transmission over Spanish land lines).

Both the Western Union and the Atlantic and Pacific Telegraph Companies have asked for permission to lay down pneumatic tubes in New York. The former also contemplates placing their town wires underground.

The number of messages passing over the lines of the Cuba Submarine Telegraph Company during the month of November, was 2,520, estimated to produce £2,500, against 1,621 messages, producing £1,904 in the corresponding month of last year.

The *St. Martin's Magazine*, which is produced and supported by members of the Postal Telegraph Service, is publishing a series of photographs of eminent men in the service. The following have already appeared:—Lord John Manners, Messrs. Scudamore, Baines, and Fischer. They are very well done, and form quite a new feature in telegraphic literature.

We learn from the Argentine Republic, from Buenos Ayres, that the construction of a short land line, to complete the communication from Buenos Ayres, has been concluded. Martin Garcia is an island in the centre of the River Plate, where it is formed by the confluence of the River Parana and Uruguay. The cable (26 miles in length) had been sent out for torpedo purposes; it consists of one wire, and is laid between Martin Garcia and San Isidio, whence to Buenos Ayres is 15 miles of land line.

We have been favoured with some copies of the Indian *Telegraphic Journal*, a bi-monthly magazine of electrical science. It is printed at Lahore, and circulates amongst the operating department of the Indian Government telegraphs. It contains questions and papers on elementary mathematics and on the elements of magnetism and electricity, and it indicates a healthy desire for improvement in that large class of telegraphists.

With regard to the interruption of the Eastern Company's cable, and a short interruption in the Indo-European route, Major J. U. Bateman-Champain, R.E., Director-in-Chief Indo-European Government 55, Parliament-street, writes:—"The Eastern Company's cable is at present disabled near Aden. A few days ago an interruption of some hours duration (caused by violent storms in the neighbourhood of Kertch) occurred on the Indo-European Company's line, and communication with India was very generally supposed to be altogether suspended. It seems right, therefore,

for me to remind the public of the existence of a third separate telegraphic route between England and India, viz., that by Constantinople, Bagdad, and the Persian Gulf. So soon as I was informed of the break on the Indo-European Company's line, I despatched an urgent telegram to the Indian Director-General at Calcutta. My message, directed 'viâ Turkey,' occupied 15 hours 39 minutes in transmission, while the reply from Calcutta to London took 4 hours 38 minutes. I am officially informed by the Ottoman Telegraph authorities that the line from the Persian Gulf through Constantinople and by Valona to England is in satisfactory order, and that every care is taken to ensure the rapid transmission of Indian messages. In fact the three lines to India, viâ Teheran, viâ Turkey, and viâ Suez, have never since their establishment been simultaneously interrupted, and in the interests of the public and the press I beg the favour of your inserting these explanatory remarks in your journal.'

The following sweeping alteration has been made in the mode of signalling telegrams in the Postal Telegraph Department—

1 (a). *Inland Telegrams.*—The number of words in the *text* of the message only is to be counted and signalled. The words in the addresses and instructions, which have hitherto been counted, will thus be excluded from the number signalled.

1 (b). *Foreign Telegrams.*—In foreign telegrams the number of chargeable words only is to be counted and signalled.

2. The charges collected on foreign telegrams are not to be signalled.

3. The word "From," standing before the address of the sender, is not to be signalled.

4. Instead of signalling the word "To," the separation between the address of the sender and of the receiver of the message is to be made by means of the signal - - - - (i i).

5. The signal DQ is to be replaced by the signal - - - - (i i).

6. The signal MM is to be abolished, and the Office of Origin, and instructions (if any), are to be signalled *after the code time*, instead of, as at present, after the text of the message.

7. The signal RT, which has hitherto preceded the acknowledgment, is no longer to be used, but the name of the addressee is to be repeated without any preliminary signal.

Under these alterations the order of signalling a telegram will be as follows:—

The prefix S (or X).
The Code Time.
The Office of Origin, and instructions (if any).
The number of words in the *text*. (In foreign telegrams the number of chargeable words).
The name and address of the sender of the message.
The break signal - - - -
The name and address of the receiver of the message.
The break signal - - - -
The text of the message.
The signal - - - — - denoting the completion of the message.
The Receiving Clerk will then give the acknowledgment, i.e.,—
The name of the addressee, followed by the repetition of figures and doubtful (if any) and the signal - - - — -

The effect will be to reduce considerably the number of service signals, and thereby to increase the capacity of wires for the transmission of messages.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

THE following is an abstract of a paper read "On Cable-Borers," by G. E. PREECE.*

The first appearance of any damage done to a submarine cable appeared to the Levant cable, laid by Mr. NEWALL, who speaks of the destruction of the hemp by a species of 'teredo.' Mr. SIEMENS speaks to the same effect, and says, 'This cable, which was laid in 1858, and taken up again last summer (1859), was found to be beset by another enemy in the shape of millions of small shell-fish or snails, accompanied by small worms, which had completely destroyed the unsheathed hemp, and eaten some circular holes in the gutta-percha.' Professor HUXLEY wrote as the result of his examination of these shells: "The specimens you sent me remove all doubt as to the nature of the mischief-maker in the cable. It is a bivalve shell-fish, the xylophaga, closely allied to the ship-worm (teredo), but distinguished from it, among other peculiarities, by not lining its burrow with shelly matter. The zylophaga turns beautifully cylindrical burrows, always against the grain, in wood; and I have no doubt it perforated the hempen coating of the cable in the same way. On meeting the gutta percha it seemed not to have liked it, and to have turned aside, thus giving rise to the elongated grooves which we see. Nothing is known, so far as I am aware, of the range in depth of zylophaga, so that I cannot answer your enquiry as to whether it is probable that cables immersed in 600 to 2,000 fathoms of water would be attacked or not."

In 1860, several portions of cable covered with hemp and steel wire were picked up in the Mediterranean off Minorca; these were found in places, and up to deep water, very much attacked by

* Read at the Meeting, 24th November. See page 279.

xylophaga. The hemp between the steel wires being eaten away into holes with the regularity and spacing of those in a cribbage-board. As in previous cases the guttapercha was penetrated to various depths, but not more than the size of the shell-fish. It was generally considered that the xylophaga did not penetrate, owing to its dislike to guttapercha; but some persons at the time, thought there was a great deal of doubt upon the point, for there was no sign amongst the great length of cable so damaged, of any dislike, the main sign being that there had been *no time* for further penetration.

Subsequently some specimens were forwarded from Norway, giving the usual marks of a borer.

These marks have been noticed in many of the cables in the English Channel, and the French Atlantic cable off Brest, and the Anglo-American off Valentia bear similar marks.

In the repairs lately executed to the Key West and Punta Rasa cable the teredo was again visible, and it may be assumed that various kinds of borers may be met with all over the world.

Round the English coast there is a small borer which, where it can get at the cable, penetrates direct to the conductor, and produces a fault. In the cables across the Irish Sea, to Wexford and Dublin, these "borers" have been met, but on the Welsh side.

During some repairs to the Holyhead-Dublin cable, it was noticed that "at about six miles from Port Crugmor (the landing-place), at every broken wire and open place in the sheath, all the inner hemp serving is completely eaten away by worms, leaving the percha core exposed, which in one or two places is scored from the same cause."

At other points the guttapercha was found pierced directly inwards, and a small worm found in each hole. At the same spot the hemp was found eaten away, and two or three different varieties of worms were noticed. Fortunately some specimens of these were obtained and preserved in spirit. When they were brought to London Mr. CULLEY, of the General Post Office, forwarded some specimens to Dr. CARPENTER, F.R.S., a gentleman well known for his investigation into marine life, for examination and report.

SIR,—I exceedingly regret the delay which has occurred in my reply to your communication of the 27th November last, with reference to the marine animals by which the Telegraph Cables are attacked.

Had I relied on my own judgment alone, I should have been able to answer you at once, and thought that I recognized all your specimens as types with which my marine researches have made me familiar.

But in a matter of such importance I judged it better to obtain a corroboration or correction of my own judgment from the naturalists who rank as the highest authorities in this country on (1) marine worms, and (2) crustaceans.

Dr. Mackintosh, who is now bringing out a complete work on the marine worms of Great Britain, and who is extremely conversant with their habits as well as with their form and structure, recognizes three types, *Lepidonotus equamatis*, *Evarne impar*, and *Nereis pelagica*, all well known British forms; and says, "I agree with you in acquitting them of all share in making the perforations in the coverings of the cable. They had only been lurking (after their wont) in the holes made by other forms."

The Rev. William Norman (whose letter I only received this morning), agrees with me in identifying the minute crustacean as the *Limnoria lignorum* of Rathké, known to British naturalists as the *Limnoria terebrans*. This is a most destructive creature, whose ravages have long been a source of great injury to the wood work of piers, bridges, harbour works, &c., often erroneously attributed to the borings of the teredo, a full description of its structure and habits was given by Dr. Coldstream in the Edinburgh New Philosophical Journal, vol. xvi, p. 316.

Clearly, therefore, it is the *Limnoria* that does the mischief to your cables. As its ravages were long ago noticed at Dublin, it must be an old inhabitant of the Irish sea. It is so small a creature that it would easily make its way through any fissure left by the separation of the wires of the iron sheathing; and it would seem to me that the overlapping copper riband of Messrs. Siemens would afford a surer protection.

Trusting that this report will be satisfactory to you,

I remain,
Your obedient Servant,
(Signed) WM. B. CARPENTER.

R. S. Culley, Esq.

The annual general meeting was held on Wednesday, the 8th December; Mr. LATIMER CLARK, President, in the Chair.

The names of twelve new candidates were announced.

The Council reported that they had transferred Mr. WALTER HANCOCK to the class of Member.

The Secretary then read the report of the President and Council for the year 1875, of which the following is an abstract:—

Attention was drawn to the kindness of the Institution of Civil Engineers in allowing the Society to use their theatre for the meeting, and to whom the thanks of the Society were largely due.

The numerical progress of the Society was satisfactory, the increase during the year being 115 members of all classes; foreign members, 41; members, 25; associates, 47; students, 2. The increase being particularly striking as regards foreign members, the increase in the previous year being 126 members of all classes.

The total number of members of all classes amounted to 763, against 648 of 1874, and consisted of honorary members, 4; foreign members, 122; members, 227; associates, 393; students, 17; total, 763.

Allusion was made to the death of Mr. CARL BECKER, and also to Sir CHARLES WHEATSTONE. The report gave further a resumé of the meeting during the past year, and of the work done. It was announced that the Council had arranged for the publication of the Journal quarterly, and it was proposed that in future the ballot should be taken monthly only.

It was announced that the Ronald's Library was in progress of arrangement, and that the printing of the catalogue was being pushed forward.

The ballot for the election of President and

Officers for the year 1876 was then taken with the following result:—

President—C. V. Walker, F.R.S.

Vice-Presidents—Professor Abel, F.R.S.; Major Bateman-Champain, R.E.; R. S. Culley, C.E.; Professor Foster, F.R.S.

Members of Council—Professor W. G. Adams, F.R.S.; H. G. Erichsen; Edward Graves; Colonel Glover, R.E.; Charles Hockin, C.E.; Major Malcolm, R.E., W. H. Preece, C.E.; Robert Sabine, C.E.; Carl Siemens, C.E.; C. E. Spagnoletti, C.E.; Lieut.-Col. Stotherd, R.E.; Cromwell F. Varley, F.R.S.

Associates—O. Heaviside, J. Sivewright, M.A., W. J. Tyler.

Hon. Treasurer—Major Webber, R.E.

Hon. Secretary—Major Frank Bolton.

A paper was read on "Underground Telegraphs—The London Street Work," by Charles Fleetwood, an abstract of which will appear in our next.

The following candidates were balloted for and duly elected:—

Foreign Members—L. Arisz, the Hague; C. Brieve, ditto; Hugh Nielson, Toronto, Canada; Don Antonio Oloriz, Santander.

Members—John Ahern, Manchester; John F. H. Betts, London; Walter C Johnson, Charlton.

Associates — E, Castle, the Temple; George Dubern, India Government Telegraphs; George W, Hook, Post Office Telegraphs; Walter Judd, Eastern Extension Telegraph Company; John J. Payn, Eastern Telegraph Company; James J. Philpott, Postal Telegraphs; William N. Tiddy, School of Telegraphy; R. A. Warner, Buenos Aires; Horatio Yeates, London.

Sergeant-Major W. Turner, R.E.; Sergeant-Major John Ross, R.E.; Sergeant E. Morrison, R.E.; Sergeant E. Emms, R.E.; Sergeant J. Oldershaw, R.E.; Corporal A. Richards, R.E.; Corporal F. Kenney, R.E.

The meeting then adjourned.

INTERNATIONAL EXHIBITION OF ELECTRICAL APPLIANCES TO BE HELD AT PARIS IN 1877.

An International exhibition of electrical sciences will be held at the Palais de l'Industrie at Paris in 1877. This exhibition will last four months.

The various objects to be exhibited have been divided into 18 classes, under the following heads:—

Class 1.—The history of electricity, the earliest discoveries, primitive instruments and apparatus, instruments of the principal inventors and first masters.

Class 2.—Educational apparatus, instruments for use in physical laboratories for the demonstration of Static and Dynamic electricity.

Class 3.—Generators of electricity, Batteries, instruments for the production of currents, induction machines, raw and manufactured material used for the production of electricity.

Class 4.—Electro magnetism, the electro magnet, its uses, effects, and stages of manufacture; magneto electric machines.

Class 5.—Electric telegraph, electric wires and cables, bells, signals, transmitting and receiving apparatus, sounders, dial instruments, embossers, writers, &c., domestic telegraphy.

Class 6.—Electric clockwork, clocks, regulators, chronometrical receivers, chronoscopes, and chronographs.

Class 7.—Railways, warning and protection signals, block signals, and electric brakes.

Class 8.—Electric motors, electric engines, revolution indicators, warning apparatus in workshops and manufactories, mechanical application of electricity for domestic purposes.

Class 9.—Electric light, lighting of towns, manufactories, lighthouses, subterranean and submarine lights, instantaneous lighting application to photography.

Class 10.—Electro chemistry, chemical action of electricity, electro metallurgy, organic synthesis and analysis.

Class 11.—Electroplating, application of electro chemistry to fine arts, gilding, silvering, nickelisation, coppering, &c.; reproduction of medals, statues, bas-reliefs, &c.

Class 12.—Electrotyping, the application of electricity to printing and engraving, electrotyped cliches, electro chemical engraving, engraving machines.

Class 13.—Medical electricity, application of electricity to physiology, therapeutics and surgery, baths, brushes, galvanic chains, galvano caustics.

Class 14.—Meteorological electricity, thunderstorms, lightning protectors, earth currents, compasses, observatory apparatus.

Class 15.—Military art, special telegraphy, artillery engineering, surveying.

Class 16.—Marine, signals of command and distress, submarine defence and attack torpedos, marine compasses, nautical soundings.

Class 17.—Various applications, electric trinkets, application of electricity to conjuring and phantasmagoria, electric toys.

Class 18.—Bibliography, catalogued and indexed collection of all works, French and foreign, bearing on practical or theoretical electricity.

INVIOLABILITY OF TELEGRAPH MESSAGES.

The prosecution instituted against a Newry shipbroker, for inducing a telegraph clerk, by pecuniary bribes, to give him information respecting the arrival of foreign vessels, has excited, from its novelty, considerable attention. From what transpired before the Newry Bench on Monday, it seems that the accused, who occupied a respectable position as a general grocer as well as shipbroker, put himself in communication with a telegraph clerk named Whittaker, with the object of inducing him to intercept and disclose certain messages. After some time the boy was indnced to enter upon this very dishonest and dangerous course for a consideration of half-a-crown for every message disclosed. Because of some complaints made to the local Postmaster, suspicions were excited, and the collusion between the clerk and shipbroker detected. The former was summarily dismissed, and a prosecution entered against the latter for inducing Whittaker to commit a misdemeanor. The prisoner was committed for trial at the Downpatrick Assizes, bail being accepted for his appearance. It is only right and proper that the Post Office authorities should take the most stringent

measures against the persons implicated in these proceedings. Telegraph officials are entrusted with a highly responsible duty. In point of fact nearly every man who sends away a message makes them his confidants. Upon their strict honesty and trustworthiness a great deal often depends. If confidence were once shaken in the integrity of telegraph officials the usefulness of the system would be in a great measure destroyed. The inviolability of a message is not to be outraged with impunity, if at all possible, in even a single case. Hence we view with satisfaction the steps which the Post Office authorities have taken. The fact that the Newry prosecution is the first that has been instituted, at least in Ireland, under an act passed for the protection of the senders and receivers of telegrams, shows unmistakably how trustworthy the officials, as a body, are. It is conclusive testimony of the efficient and faithful manner in which they perform their duties. Nothing could be more creditable to the body than the fact that the Newry prosecution has been the first. For the sake of all parties let us trust it will be the last.—*The Derry (Ireland) Journal.*

THE BAKERIAN LECTURE.

An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit.

By CHARLES WHEATSTONE, Esq., F.R.S.,

Professor of Experimental Philosophy in King's College, London, Corresponding Member of the Academy of Sciences at Paris, &c.

Received June 15.—Read June 15, 1843.

SECTION 1.—I intend in the present communication to give an account of various instruments and processes which I have devised and employed during several years past for the purpose of investigating the laws of electric currents. The practical object to which my attention has been principally directed, and for which these instruments were originally constructed, was to ascertain the most advantageous conditions for the production of electric effects through circuits of great extent, in order to determine the practicability of communicating signals by means of electric currents to more considerable distances than had hitherto been attempted. In this endeavour, guided by the theory of Ohm and assisted by the instruments I am about to describe, I have completely succeeded. But the use of the new instruments is not limited to this especial object; they will, I trust, be found of great assistance in all inquiries relating to the laws of electric currents, and to the various and daily increasing practical applications of this wonderful agent. An energetic source of light, of heat, of chemical action and of mechanical power, we only require to know the conditions under which its various effects may be most economically and energetically manifested, to enable us to determine whether the high expectations formed in many quarters of some of these applications are founded on reasonable hope, or on fallacious conjecture. The theory we now possess is amply sufficient to direct us rightly in this inquiry, but experiments have not yet been sufficiently multiplied to enable us to obtain, except in a few cases, the numerical values of the constants which enter into various voltaic circuits; and without this knowledge we can arrive at no accurate conclusions.

Section 2.—The instruments and processes I am about to describe being all founded on the principles established by Ohm in his theory of the voltaic circuit, and this beautiful and comprehensive theory being not yet generally understood and admitted, even by many persons engaged in original research, I could scarcely hope to make my descriptions and explanations understood without prefacing them with a short account of the principal results which have been deduced from it. It will soon be perceived how the clear ideas of electro-motive forces and resistances, substituted for the vague notions of intensity and quantity which have been so long prevalent, enable us to give satisfactory explanations of most important phenomena, the laws of which have hitherto been involved in obscurity and doubt. Viewing the laws of the electric circuit from the point at which the labours of Ohm has placed us, there is scarcely any branch of experimental science in which so many and such various phenomena are expressed by formulæ of such simplicity and generality; in most of the physical sciences the facts of observation and experiment have kept pace with theoretical generalization, in this science alone they had gone on accumulating in prolific abundance without any successful attempt having been made to reduce them to mathematical expression. But this is now happily effected, and what has hitherto been mere matter of speculative conjecture is removed into the domain of positive philosophy.

By *electro-motive force* is meant the cause which in a closed circuit originates an electric current, or in an unclosed one gives rise to an electroscopic tension. By *resistance* is signified the obstacle opposed to the passage of the electric current by the bodies through which it has to pass; it is the inverse of what is usually called their conducting power.

When the activity of any portion of the circuit is increased or diminished, either by a change in the electro-motive force or in the resistance of that portion, the activity of all the other parts of the circuit increases or decreases in a corresponding degree, so that the same quantity of electricity always passes in the same instant of time through every transverse section of the circuit.

The force of the current is directly proportional to the sum of the electro-motive forces which are active in the circuit, and inversely proportional to the total resistance of all its parts, or in other words the force of the current is equal to the sum of the electro-motive forces divided by the sum of the resistances.

Let F denote the force of the current, E the electro-motive forces, and R the resistances: then

$$F = \frac{E}{R}.$$

The length of a copper wire of a given thickness, the resistance of which is equivalent to the sum of the resistance in a circuit, Ohm calls a *reduced length*, an expression which it will frequently be found convenient to employ.

If the electro-motive forces and resistances in a

circuit are proportionately increased or diminished the force of the current remains the same, or

$$\frac{E}{R} = \frac{n\,E}{n\,R}.$$

Hence a single voltaic element, or a battery consisting of any number of exactly similar elements, if no additional resistance be interposed in the circuit, produces the same effect. Also a thermo-electric element and a voltaic element will produce the same effect when the greatly inferior electro-motive force of the former is compensated by a corresponding decrease in its resistance; in a thermo-electric arrangement the resistance is in general small, because the circuit is entirely metallic, while in a voltaic element the resistance of the liquid is always considerable.

Any interposed resistance weakens the force of the current, but less so as it is smaller in proportion to the other resistances in the circuit. Hence in two circuits, both producing currents of equal force, when the same resistance is introduced, the strength of the two currents may be weakened in very different proportions. A single voltaic element, $\frac{E}{R}$, and a series consisting of any number of such elements, $\frac{n\,E}{n\,R}$, form circuits in which the currents have the same force, but very different results will be obtained according as the added resistance is great or small compared with the original resistances in the circuits; if it be small, the effects of the two circuits will remain sensibly the same; but if it be large, the resistance that weakens to a very great extent the current in the circuit of the single element produces but a trifling diminution in that of the series. This explains the necessity of employing a series to overcome considerable resistances. The same remarks will apply to the comparison of a thermo-electric with a voltaic circuit.

The following is the general formula for the force of the current in a voltaic circuit when completed by a connecting wire; the metallic plates of the voltaic elements being parallel to each other and of equal size:—

$$F = \frac{n\,E}{\frac{n\,R\,D}{S} + \frac{r\,l}{s}}.$$

F is the force of the current, E the electro-motive force of a single element, n the number of elements, R the specific resistance of the liquid, D the thickness ot the liquid stratum or distance of the plates, S the section of the plates in contact with the liquid, r the specific resistance of the connecting wire, l its length, s its section.

Expressed in words we have the following laws:—

The electro-motive ferce of a voltaic circuit varies with the number of the elements, and the nature of the metals and liquids which constitute each element, but is in no degree dependent on the dimensions of any of their parts.

The resistance of each element is directly proportional to the distance of the plates from each other in the liquid, and to the specific resistance of theli quid, and is also inversely proportional to the surface of the plates in contact with the liquid.

The resistance of the connecting wire of the circuit is directly proportional to its length and to its specific resistance, and inversely proportional to its section.

The limits of this communication will not allow me to dwell longer on the consequences of Ohm's theory of the electric circuit; for further developments I must refer to the author's work, 'Die Galvanische Kette mathematisch bearbeitet,' Berlin, 1827, a translation of which has appeared in Taylor's Scientific Memoirs, vol. ii.; to his various other memoirs published in Schweigger's 'Jahrbuch der Physik;' and to the more recent applications of the theory made by Fechner, Lenz, Jacobi, Poggendorff, Pouillet, &c.

There is, however, one class of considerations which it is indispensable I should bring forward, because upon it are founded many of the instruments and processes which I shall have occasion hereafter to mention,—I allude to the laws of the distribution of the electric current in the various parts of a circuit, when a branch conductor is placed to divert a portion of the current from a limited extent thereof.

Let λ be the reduced length of the portion of the circuit from which the current is partially diverted, λ' that of the wire which diverts the current, and L that of the undivided part of the circuit. The force of the current in each of the adjacent conductors, λ and λ', can be shown to be in the inverse ratio of their reduced lengths, and the reduced length of a single wire, which, substituted for both, would not alter the force of the current, to be $\frac{\lambda\lambda'}{\lambda+\lambda'}$, which we will designate by Λ.

The force of the current in the original circuit before the introduction of the branch wire will then be expressed thus:—

$$F = \frac{E}{L+\lambda},$$

and the strength of the current in the three different portions of the altered circuit by the following expressions:—

In the principal or undivided portion L,

$$F_1 = \frac{E}{L+\Lambda} = \frac{E\,(\lambda+\lambda')}{L\,(\lambda+\lambda') + \lambda\lambda'}$$

In the portion from which the current has been partially diverted, or λ

$$F_2 = \frac{E}{L+\Lambda} \cdot \frac{\Lambda}{\lambda} = \frac{E\lambda'}{L\,(\lambda+\lambda') + \lambda\lambda'}$$

In the portion which partially diverts the current, or λ',

$$F_3 = \frac{E}{L+\Lambda} \cdot \frac{\Lambda}{\lambda'} = \frac{E\lambda}{L\,(\lambda+\lambda') + \lambda\lambda'}$$

Section 3.—It is seldom that any real advance is made in a scientific theory without a corresponding change in its terminology being required. Now that it is proved beyond doubt that the various sources of continued electric action differ from each other only in the amount of their electro-motive forces, modified by the resistance of the circuit of which they form part, it becomes of importance, in order to give precision to our statements and to avoid circumlocutions otherwise inevitable, to adopt general terms to express the source of a current without reference to the peculiar mode of its production; I shall therefore employ the word *Rheomotor* to denote any apparatus

which originates an electric current, whether it be a voltaic element or a voltaic battery, a thermo-electric element or a thermo-electric battery, or any other source whatever of an electric current; when speaking of a single element I shall term it a rheomotive element, and what is usually called a voltaic or thermo-electric pile or battery I shall term a rheomotive series. I shall still use the ordinary expressions when I have to refer to the specific sources of the production of electric currents, and when I employ the essential terms they must be understood to apply to all these sources indifferently.

The want of a general term to designate an instrument to measure the force of an electric current without reference to its particular construction has been long felt. I shall use the word *Rheometer* for this purpose, continuing occasionally to employ galvanometer, voltameter, &c., to distinguish the particular instruments to which these names have been applied, though perhaps the terms Magnetic, Chemical, Calorific, &c. Rheometer would be more appropriate.

This may be a proper place to explain a few other terms which I have frequent occasion to use, though not in the course of the present communication. By *Rheotome* is meant an instrument which periodically interrupts a current, and by *Rheotrope* an instrument which alternately inverts it. A *Rheoscope* is an instrument for ascertaining merely the existence of an electric current. The word *Rheostat* will be hereafter explained.

I have not introduced these terms, which will be found greatly convenient and will enable us to state general propositions much more clearly, without good authority. The word Rheophore was employed by Ampère to designate the connecting wire of a voltaic apparatus, as being the carrier or transmitter of the current; and the word Rheometer, first proposed by Peclet as a synonym for galvanometer, has been generally adopted by the French writers on physics.

Section 4.—The method of obtaining the constants of a rheophoric circuit adopted by Fechner, Lenz, Pouillet, &c., in their experimental verifications of Ohm's theory, is essentially the following:—

The resistance of a circuit is determined by observing the force of the current, first without any extra interposed resistance in the circuit, and afterwards when a known resistance is added. Then

$$F = \frac{E}{R}, \text{ and } F' = \frac{E}{R+r} \quad \therefore \frac{F}{F'} = \frac{R+r}{R},$$

from which equation the value of R, all the others being known quantities, is easily deducted.

$$R = \frac{F'}{F - F'} r.$$

The electro-motive force of a circuit is ascertained by multiplying the force of the current into the total resistance; for since

$$F = \frac{E}{R} \quad \therefore E = FR.$$

The principle of this method is extremely simple, but the difficulty of determining immediately the force of the current by means of a galvanometer is an obstacle to its general employment. Fechner measured the force of the current by the number of oscillations of the needle when placed at right angles to the coils, a very tedious operation; and others have employed the deviations of the needle, the corresponding degrees of force having been previously determined by some peculiar process, or inferred from some rule depending on the particular construction of the instrument. Another impediment to the use of a galvanometer to measure the force of a current arises from the changes in the magnetic intensity of the needle which frequently occur, especially when it has been acted upon by too strong a current.

The principle of my method is that of employing variable instead of constant resistances, bringing thereby the currents in the circuits compared to equality, and inferring from the amount of the resistance measured out between two deviations of the needle, the electro-motive forces and resistances of the circuit according to the particular conditions of the experiment. This method requires no knowledge of the forces corresponding to different deviations of the needle.

To apply this principle it is requisite to have a means of varying the interposed resistance, so that it may be gradually changed within any required limits. I have contrived two instruments for effecting this purpose, one intended for circuits in which the resistance is considerable, the other for circuits where the resistance is small.†

(To be Continued.)

* Massbestimmungen über die Galvanische Kette. Leipzig' 1831, p. 5.

† It appears that the idea of constructing an instrument of this kind had also occurred to Professor Jacobi of St Petersburg. When I explained to this eminent experimentalist my instruments and processes in the beginning of August, 1840, he informed me that he had himself constructed a similar instrument which he had exhibited to the Academy of Sciences at St. Petersburg, though no description of it had yet been published, and he at the same time showed me a drawing of it. This instrument, which he has since called an Agometer, differs in mechanical construction from either of mine, and is less convenient to manipulate; but its principle is the same. In a communication which Professor Jacobi made in the following month to the Meeting of the British Association at Glasgow, and which was published in the Athenæum of No. 678, 1840, he thus alludes to the subject:—

"Before proceeding, I may be permitted to make some remarks concerning an instrument which I laid before the Academy of Sciences in the commencement of this year. It is destined to regulate the galvanic current, and is of value in many investigations of this kind. During my sojourn in London, Professor Wheatstone has shown me an instrument, founded exactly on the same principles as mine, and with very insignificant modifications and differences. Now, it is quite impossible that he should have had the least notice of my instrument; but as it is probable that its use may be greatly extended, I must add, that while I have only used this instrument for regulating the force of the currents, he has founded upon it a new method of measuring these currents, and of determining the different elements or constants which enter into the analytical expressions, and on which depends the action of any galvanic combination. It is principally to the measure of the electro-motive force, by those means, that Mr. Wheatstone has directed his attention; and he has shown me, in his unpublished papers, very valuable results which he has obtained by this method."

Professor Jacobi has since his return employed my method of determining the constants of a voltaic circuit. The memoirs in which his results were given were republished in Poggendorff's "Annalen der Physik," vol. liv. No. 2 for 1841, and vol. lxii. No. 9, for 1842. To the latter the learned editor, who has made most valuable researches himself in the same path, has appended (p. 89) the following note:—"I will take this opportunity to call to mind that I applied the same method (or at least one identical to it in principle) before it was communicated to the author by Mr. Wheatstone. See the Annals, vol. liii. p. 526." I have referred to this volume and find that it was published in the latter part of 1841, while my communication to Professor Jacobi was, as above stated, made in August, 1840. I may also mention, that the experimental process employed by Professor Poggendorff had no resemblance whatever to mine, and the result he sought was likewise different; the mathematical principle of the method was however in the single case he investigated undoubtedly the same.

SIEMENS' AUTOMATIC CYLINDER TRANSMITTER.

THIS instrument unites the two functions, of composing and transmitting messages automatically by means of a *single* apparatus of comparatively small dimensions.

These two functions are independent of each other, although both are being carried on at the same time; the apparatus being thus distinguished from other automatic instruments by *not* requiring *two* different portions for composing the message (generally by means of perforated paper) and transmitting the same.

The Cylinder Transmitter is brought into the direct circuit of the line, and the sending of a message is caused by pressing down finger-keys, each of which corresponds to a letter, number, or mark of punctuation, which is written on the knob of the key.

The rapidity with which these finger-keys may be worked depends upon the velocity of the revolving cylinder, the speed of which is independent of the working of the finger-keys.

The message received is in Morse signals, but the difference in the length of these signals does not depend upon the time the finger-keys are held down, as the signals and spaces always appear of their normal length, whether the manipulator occupies more or less time between the pressing down of two following keys; the blank spaces between two words are produced by a special key called the "blank key."

In order that the instrument may occupy the smallest possible space, the keys are disposed in seven rows of seven keys each, in such a manner that those letters which most frequently occur are placed most conveniently to the position of the hands.

The entire instrument covers a surface 21 c.m. ($8\frac{1}{2}''$) by 33 c.m. ($13\frac{1}{4}''$), of which about 20 c.m ($8''$) by 20 c.m. ($8''$) belong to the finger-key arrangement. The highest part of the instrument is 29 c.m. ($11\frac{1}{2}''$).

The Automatic Cylinder Transmitter can be arranged to send currents in the same direction as well as alternating currents, with or without earth discharge, according to the circuit for which it is required.

In the first case the receiving instrument may be a simple Morse inker, and, in order to furnish a station with the automatic instrument, it is only required to change the Morse transmitting key for the Automatic Cylinder Transmitter.

The transmitting capacity of the apparatus depends upon the rapidity with which the telegraphist is able to work the finger-keys. A thoroughly efficient telegraph operator could work five keys a second, which under the condition that the mechanism of the apparatus be regulated accordingly, produces 300 signs in a minute, including the spaces between the words. If we take 200 letters as being required for a complete message (33 words), the apparatus thus transmits 90 messages per hour, which is about double the practical capacity of the "Hughes" apparatus.

The Cylinder Transmitter thus offers the advantages of automatic telegraphy (that is: augmented speed, with exclusion of defect arising from transmission by hand), without adding any difficulties to the telegraph service, and the Automatic Transmitter may be used at any moment in place of the usual Morse transmitting key.

Figs. 1 and 2 show the principal points of the instrument, omitting the less essential parts for the sake of clearness. The large plate gives a perspective view of the entire apparatus.

The characteristic part of the instrument consists of a cylinder D, which revolves on its own axis.

The periphery of the cylinder is fitted with sliding-pins *s s* (see fig. 2) placed close to each other, and parallel to the axis of the cylinder.

These pins, when pushed at one end by means of the puncher *n*, are displaced, to a certain extent, in the direction of the axis.

Groups of displaced pins of certain combinations constitute the various types for the automatic transmission of the signals, so that three displaced pins in close connection represent a *dash*, and a single displaced pin between two in their normal position represents a *dot;* one or more not displaced signify an interval of more or less length.

When pressing down a finger-key a group of pins is displaced from its normal position at the circumference of the cylinder, the group always corresponding to the letter of the finger-key.

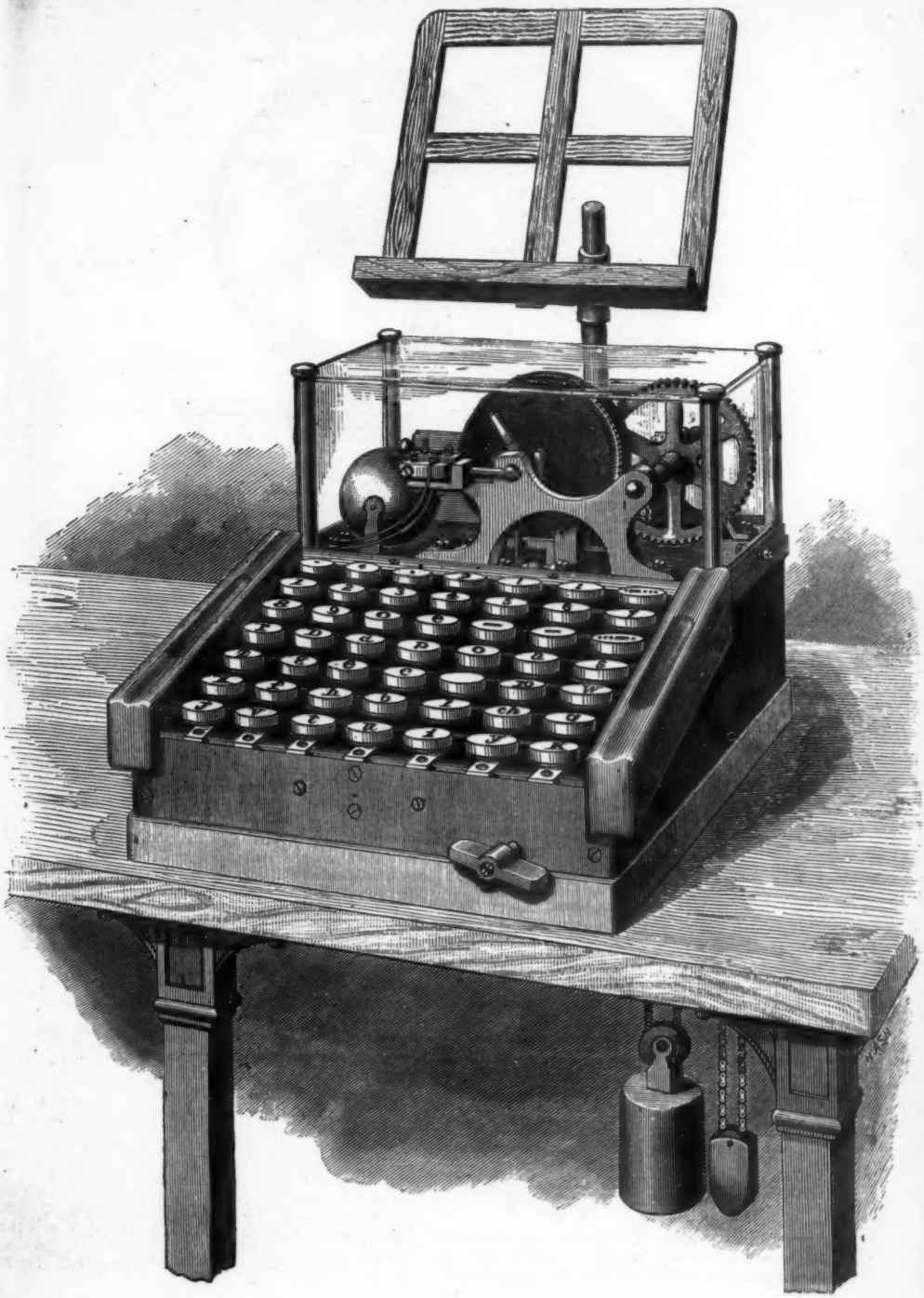
The cylinder rotates under the effect of a weight or watchspring to such an extent as corresponds to the length of the given signal, including the space between it and the next signal; the cylinder then presents a new series of pins to the punchers *n*, which latter effect the displacement of pins through the movement they receive from the finger-keys.

Each finger-key T (see fig. 2, of which only one is shown in the drawing) is in connection with a vertical metal-plate S in such a manner that, when pressing down the finger-key T, one of these plates is pushed forward. The projections upon these metal plates S push forward a series of horizontal plates Q Q, of which there are 19, each having a corresponding double lever H. These levers are provided with punchers *n*, so that when the plates Q are pressed forward they act upon the levers H, which push forward the sliding-pins *s s* (placed at the circumference of the cylinder D) by means of the punchers *n*.

A pointer *i* connected to the axis *m* (over which the cylinder D rotates independently) is geared to the clockwork within the cylinder, and is set in motion by the spring F, which, being attached to the spindle *m*, is caused to wind up each time the cylinder rotates.

The cylinder D has ratchet teeth *c*, in which engages a spring pawl *a*, having an inclined projection *f*, and while this pawl is engaged with the ratchet teeth the cylinder remains at rest. When one of the levers H is moved by the action of a finger-key, so as to push forward one or more of the pins, these latter, at the same time, disengage the pawl *a*, and the cylinder D, acted on by the weight P, and clock-wheels N M, revolves till the pawl *a* again drops into gear.

The pawl is held out of gear as long as any of the protruded pins *s* are passing over its inclined projection *f*, and the width of this projection allows the cylinder to rotate for an additional length, which corresponds to the usual space between the signals,



It may here be remarked that the punchers *n* act in such a manner that, after pushing the pins

tacts to be made, by which currents are sent into the line wire.

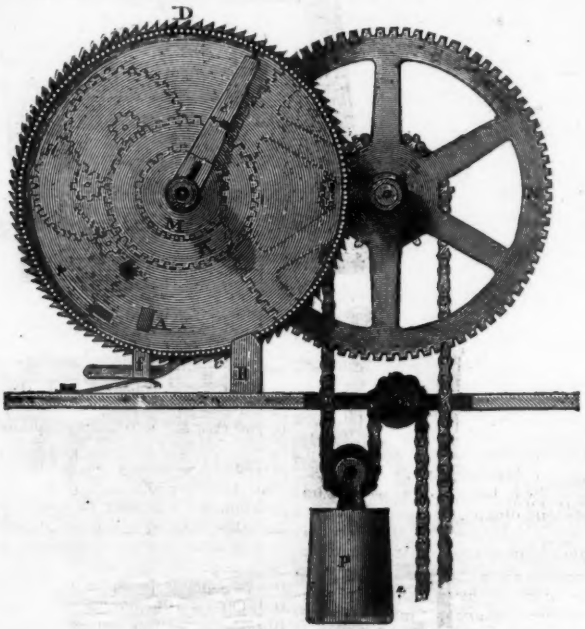


FIG 1.

forward, they pass beneath the line of pins, and therefore do not impede the rotation of the cylinder.

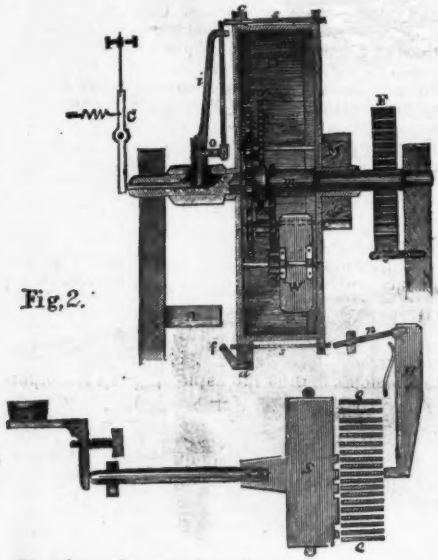


Fig. 2.

The pins, after passing the pawl *a*, are carried round with the cylinder in their protruded position, and the pointer *i*, in passing over them, causes con-

The mode in which the pointer *i* passes over the protruded pins (thus causing contact between battery and line) is the following:—On the pointer, near its axis, is mounted a bell-crank lever *o*, from one arm of which a wire extends radially along the pointer beyond its end, and from the other arm of which a wire extends axially through a hollow part of the spindle *m*, on which the pointer is mounted.

When the pointer *i* passes over a protruded pin the radial wire is pushed inwards. and the axial wire is thus pushed outwards, and moves a contact lever C, mounted outside the bearing of the spindle.

The pins *s s*, after having caused contact to be made, are brought round by the rotation of the cylinder, so as to pass under a fixed incline R (fig. 1), whereby they are restored to their normal position.

The contact lever C corresponds to the ordinary Morse transmitting-key, which, in this case, sends automatically, the signals into the line.t

The pointer *i* makes, together with he cylinder D, the jerking rotations, independently of its own movement in the opposite direction, the speed of the pointer being regulated by the fan W. According to the more or less rapidity with which the telegraphist presses down the finger-keys T T, either the jerking movement of the cylinder or the contrary movement of the pointer will prevail, that is to say, in the former case, the pointer will be carried further round, in the direction of the arrow of the cylinder, away from the stopper A (see fig. 1), and, in the latter case, it will approach the stopper, moving in the direction of its own arrow, or, in other words, the store of prepared letters

between the stopper A and the pointer *i* will either be dimished or augmented.

The entire rotation of the pointer is something less than one revolution, and, as soon as the pointer reaches the limit of the movement which is allowed for storing the letters to be telegraphed automatically, a bell rings, indicating to the telegraphist that the speed of working the finger-keys should be lessened.

As soon as the telegrapher stops working the finger-keys, no more pins are pushed out, the pawl *a* drops into the ratchet teeth, and stops the movement of the cylinder, whilst the pointer *i*, which may, at the time, be some distance behind, will still continue its rotation until it reaches the stopper A.

A NEW RELATION BETWEEN ELECTRICITY AND LIGHT: DIELECTRIFIED MEDIA BIREFRINGENT.

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(From the *Philosophical Magazine*.)

(Continued from page 284.)

14. *Fifth experiment.*—A compensating slip is introduced between the dielectric and the analyzer; all the other arrangements and the procedure are as in the first experiment (6). The plane of polarization being at 45° to the horizon, and the initial extinction in the polariscope perfect, the electric force is applied, and the light is well restored. When the compensating slip is now raised into the course of the beam, and stretched horizontally, the light is weakened, and, with a proper degree of tension, extinguished perfectly. As the electric action is continued, an increasing force has to be applied to the compensator to produce extinction; but the force is always of the same kind—tension exactly or nearly parallel to the lines of electric force, or compression in a direction exactly or nearly perpendicular.

After a few trials I got this phenomenon to present itself with perfect regularity. The compensator is chosen carefully (13), and inequalities of temperature avoided. A strong electric action is kept up for any convenient time, 5 or 6 seconds to 30 or 40, till the light is well restored. The slip is introduced as in the illustrative experiment (12), and carefully bent, so that the part of it crossed by the light is stretched horizontally by a continuously and slowly increasing force. In these circumstances, and constantly, the light fades away from a very considerable brightness to an extinction as pure as I have ever got in a polariscope. After this it is almost superfluous to say that, when the compensating slip is compressed in a direction parallel to the lines of force, the light restored by electric action is always distinctly strengthened.

15. *Sixth experiment.*—Distance of the spark-terminals small (say, 3 inches), the other arrangements as formerly. The electric action is kept up for a minute or more, till the light in the polariscope is certainly constant. The neutralizing plate is then moved about, and the analyzer turned (through a small angle in any case), till the light is again well extinguished. All the optical pieces being left untouched, the primary circuit is broken; the light reappears in a few seconds, and increases continuously up to a certain permanent intensity; but the compensator to produce extinction at any stage of this increase, has to be compressed in a direction parallel to the lines of force. And this is evidently as it ought to be; for what the compensator has now to do is to reinforce the failing action of the dielectric, an action which has been proved equivalent optically to compression along the lines of force (14).

16. *Seventh experiment.*—Distance of the spark-terminals small, 1½ or 2 inches. As in the preceding experiment (15), a constant effect of electric action is obtained in the polariscope, and the light again extinguished by the neutralizing plate, which is then left untouched, as well as the other optical pieces, till the end of the experiment. The electric action being still kept up, the distance of the spark-terminals is suddenly increased up to 5 or 6 inches; the light soon reappears and is allowed time to come out distinctly. When the primary circuit is now broken, the light fades away to extinction, and afterwards reappears; but before and after this passing extinction the light has contrary characters, as tested by the compensator, being extinguished in the former case by tension parallel to the lines of force.

17. From the last three experiments, or simply from the first of them, interpreted by the illustrative optical experiment (12), we infer that the dielectrization of plate glass is equivalent optically to a compression of the glass along the lines of electric force. Dielectrified glass acts upon transmitted light as a negative uniaxal with its axis parallel to the lines of force.

18. *Eighth experiment.*—All the preliminary arrangements are as in the fifth experiment (14). A strong electric action (spark of 6 inches) is kept up without ceasing for 20 minutes, and all the optical pieces are left untouched for an hour, the induction-terminals being connected with each other through the secondary coil from first to last. One thing very noticeable under such conditions is, the length of time which the light takes to fade away to extinction. In the present experiment there is a distinct, though faint, effect in the polariscope, even as long as 30 or 40 minutes after the external electric action has ceased. The effect has a constant character from first to last: the light restored by electric action is always extinguished perfectly by a right degree of tension of the compensator in a direction parallel to the lines of force. With the standard compensator (13), there is not a very great effort required for extinction at any time during the whole hour of observation.

19. *Ninth experiment.*—The analyzer is mounted in such a way that it may be moved in different directions at right angles to the beam, without rotation: the other arrangements are as in the fifth experiment. When a good effect has been obtained through the centre of the electric field, the second Nicol is moved about so as to receive the light through different parts of the dielectric.

Keeping first to the perpendicular bisector of the line joining the terminals, the intensity of the optical effect diminishes as the distance from the centre of the field increases: and this is particularly noticeable at first, while the effect is rising; but the action has always the same character, is always neutralized by horizontal tension of the compensator. As far as my means would allow, I have assured myself of the fact that, as soon as

there is a good virtual compression of the dielectric at the centre of the field, there is an effect of the same kind, a virtual compression in the same direction, beginning to manifest itself all along the equator, but more faintly as the distance from the centre of the field increases. Out of this equatorial line, and well back from the wires, the direction of apparent compression of the dielectric changes from point to point of the field, and is at some points vertical, perpendicular to the line joining the terminals. Only at points very close to the induction-wires does the compensator fail decisively to extinguish or greatly weaken the restored light.

20. In connection with the preceding facts, I may mention that under certain conditions, in the fifth experiment, the compensator does not extinguish the restored light all at the same time, but produces a very dark broad band, which descends from the outer parts of the field towards the centre, as the tension of the compensator increases. This happens for instance, though not very regularly, when the electric force is very intense from the beginning, and the optical effect is just beginning to show itself; it happens also when the lines of force are inclined to the horizon, so that the fine vertical band of flame seen through the centre of the dielectric crosses the equator of the field at about 45°. In these cases there appears to be an unusually rapid variation of birefringent action through the part examined of the electric field.

I have now done with the dielectric of plate glass. Half-a-dozen other solids were tried; and I will conclude with a short account of the only two of them which gave results worth mentioning. The great difficulty was to get a sufficiently strong superficial insulation, the masses being too small. In only one case, that of Iceland spar, was the dielectric perforated by discharge without giving a clear effect; but I think the crystal had received a predisposing flaw in the operation of boring.

21. *Dielectric of Resin.*—This is a piece very similar to the dielectric of plate glass in form, size, and adjuncts. A quantity of clear amber resin is kept at a gentle fusion for some time till it is free from air-bubbles; it is then poured into a suitable mould and left to cool. Two thick stocking-wires of steel, previously fixed in the mould, along one line through its ends, remain imbedded as induction-terminals in the solid resin, leaving less than $\frac{1}{4}$ of an inch of clear dielectric between them at the centre of the block. The polarized light enters and leaves the central part of the block through small squares of thin plate glass, which are in optical contact with the resin and parallel to each other.

This dielectric, even the best specimen of it, is far inferior to the dielectric of plate glass. It gives evidence of permanent and irregular strain in the neighbourhood of the terminals; it exerts a pretty strong photogyric action in the polariscope, separating the blue and red by a small angle; it is also imperfectly transparent for very faint light; but its chief defect is, that it allows a spark-discharge over its surface, a length of 7 inches, before the distance of the spark-terminals has much exceeded $2\frac{1}{2}$ inches. With all these deficiencies, the dielectric of resin gives a definite and regular effect; and the action is contrary to that of glass.

All the arrangements are essentially as in the fifth experiment (14). The block is tied to two insulating pillars of glass; the induction-wires of the dielectric are connected with the knobs of the secondary coil; and the light is seen through the centre of the block, midway between the terminals. A pretty good initial extinction is obtained in the polariscope between the blue and red; the light is then well restored by electric action, and the compensator is introduced between the dielectric and the second Nicol. By tension of the compensator in a direction parallel to the lines of force, the restored light is constantly and distinctly strengthened; and by compression parallel to the lines of force, it is regularly and greatly weakened, though never quite extinguished.

To test the value of these indications, I repeated the illustrative optical experiment (12) with the block of resin put in place of the large block of plate glass; and the results were satisfactory. I varied the experiment also by manipulating the block of resin itself as a compensator against the small square of compressed glass, the resin being simply pulled or pushed gently at both ends; and the results were equally distinct. The lines of stress being parallel, compression of glass and compression of the resin always reinforced each other, compression of glass and extension of the resin always counteracted each other, but never down to perfect extinction. It is true that these last results might be due more or less to the thin plates of glass which limit the resin. From all the observations, I infer that dielectrization of resin is optically equivalent to tension of the resin along the lines of force.

22. *Dielectric of Quartz.*—This is a plate perpendicular to the axis, made as for ordinary experiments in the polariscope, thickness 3 millims., length 20.' Two fine holes are drilled into the plate as in the dielectric of plate glass, their bottoms flat, and with one-sixteenth of an inch of clear crystal between them. Wires of copper are inserted in the borings, and are fixed along with the crystal to simple bearings made of glass rods; and the whole piece is coated very deeply with fused lac, a narrow window being left at the centre of the plate. The action of the crystal in the polariscope is well neutralized by a contrary plate of equal thickness; the other arrangements are as in the fifth experiment. With my rough apparatus the adjustments are so troublesome that I have executed only one short series of obervations, of which I append all the notes preserved.

Distance of spark-terminals $\frac{1}{2}$ inch: a faint but clear restoration of the light from almost perfect extinction; the compensator not working distinctly; the insulation perfect.

Distance 1 inch: the light clearly restored by electric action, and then well extinguished by tension of the compensator parallel to lines of force. The insulation is now failing, sparks passing occasionally over the service of the lac near the crystal.

Distance $\frac{3}{4}$ inch: the insulation still defective; the light well restored by electric action and then well weakened by horizontal tension, and strengthened by compression. From what I have seen in some other experiments, I think that the effects in this case and the preceding may have been produced wholly or partially by slight changes of

temperature, due to occasional spark-discharge over the surface of the crystal.

Distance again ½ inch: the insulation again good. In this case it is noticed that, before the electric force is applied, while the body of the light is barely perceptible in the polariscope, there is a short length of it from the apex downwards (due exactly through the centre of the electric field) which is perfectly extinguished. By electric action this upper part of the light is restored very clearly, and is then as clearly extinguished by tension of the compensator parallel to the lines of force.

23. Upon the whole, though better experimental results are desirable, I consider it proved that dielectrified quartz (like glass) acts upon transmitted light as if compressed along the lines of force, while dielectrified resin (unlike glass) acts as if extended along the lines of force.

24. *Theory*.—Faraday's views as to the constitution and function of dielectrics apply here very aptly.

When the induction-terminals are charged, the particles of the dielectric throughout the field are electrically polarized, and tend accordingly to arrange themselves end to end, and to cohere in files along the lines of force, just as iron filings do in a magnetic field. As far as this tendency of the polarized particles towards a file arrangement along the lines of force takes effect, there is a new molecular structure induced in the dielectric.

If we neglect the influence of ordinary strains transmitted from point to point of the solid, and assume, as a good first approximation warranted by facts (19), that the change of molecular arrangement at each point is determined solely or principally by electric force at the point, we cannot easily suppose the new structure in a dielectric, originally isotropic, to be anything else than uniaxial, symmetrical at each point with reference to the line of force through the point. And, even in the case of an æolotropic body, we may assume, as a simple and sure approximation to the truth, that th e effect of electric force is to superinduce a uniaxial structure upon the primitive structure.

The uniaxial structure thus induced by dielectrization has been experimentally detected and characterized by birefringent action in three cases. As a matter of fact, it appears to be negative in glass and quartz, but positive in resin.

The electric force has probably a certain resistance to overcome, something analagous to coercive force in the case of magnetism. A sensible time is therefore required for the development of the uniaxial structure by electric action, and for its disappearance after the electric action has ceased. Under an intense and long-sustained electric force, the new structure of the dielectric may assume the character of a very stiff, and, perhaps, permanent set, analagous to permanent or subpermanent magnetism (18). We shall see afterwards, as might indeed be expected, that there is nothing similar to this in the phenomena presented by dielectrified liquids.

Contrary electrizations rapidly succeeding one another exert contrary actions of electric polarization, but conspiring actions of molecular arrangement: they are therefore as effective as a continued electrization in one direction; and a Rhumkorff's coil is as effective as an electrical machine of equal strength.

I have made some experiments, and have had a good many reflections, bearing on other explanations of the phenomena; and I think it not unlikely that strains due to the mutual actions of intensely charged shells of the dielectric, or strains due to changes of temperature, may have something to do with the facts. But in the meantime I offer the preceding remarks as a sketch of what appears to me to be the only probable theory.

MILITARY TELEGRAPHS.

ACCORDING to the *Augsberg Gazette*, the most complete and extensive telegraphic organization is possessed by Russia. Since the changes effected in 1873 seven parks have been established, each comprising three divisions—the first destined to establish, in time of war, telegraphic communication on the most advanced line; the second, to unite the head-quarters with all the necessary points; the third to repair the conductors. The material of the first two divisions enables them to put up the wires for a length of between ten and twelve miles, to which the reserve brigade can add others ten miles long. It is only since 1856 that measures were taken in Prussia to organize a system of portable telegraphs. This material was utilized in 1864, during the war with Denmark, and in 1866, in the war with Austria. During the first campaign it was composed of two divisions; in the second, of four. It was during the war of 1866 that it was shown what invaluable services a military telegraph could render. The lesson then learned was immediately utilised, and when the war of 1870 broke out, the field telegraph was composed of 12 divisions, commanded by a superior officer. The service, as at present constituted, has no organization for times of peace; and the battalion of pioneers of the guard and the fourth battalion of pioneers in garrison at Berlin or at Magdeburg supply the elements. The first furnishes seven divisions, the second five, each division consisting of a detachment of pioneers of about 90 men, with three officers of engineers, seven telegraph *employés*, one officer and 50 soldiers of the Military Train, and each park having 13 waggons. Each waggon carries the material for laying four and a-half miles of wire, besides 1000 feet of cable, together with the Morse apparatus, with ten-pile batteries, for the establishment of stations. In Italy the military telegraph was first utilised on a grand scale during the operations against Ancona in 1861. From Ancona communication was established in two days between the army and the fleet, and between the head-quarters and the various isolated corps, as well as between one and the other of those corps—and the whole united to the Italian telegraphic system. But it was during the American War of Secession that the military telegraph, perhaps, played the most conspicuous part. During the space of three years the army laid upwards of 8000 kilometres of wire on land and 160 kilometres of cable in the sea. It was during this war that it was shown how useful the military telegraph might be made to carry out daring projects, to effect surprises, reconnaissances, requisitions, &c. The troops of partisans that were constantly operating upon the flanks of the armies were always accompanied by an experienced telegraphic operator, an important intelligence was

thus frequentiy received by the leader of the band. On one occasion, the mayor of Cincinnati having telegraphed to a Federal general, encamped 60 miles distant, that General Morgan intended to attempt to take the city by a *coup de main*, asked for his assistance. The dispatch was, however, intercepted, and Morgan himself replied, in the name of the Federal general, that he was about to proceed to Cincinnati, but that fresh horses would be required for his artillery, and these he would expect to find at a certain place which he designated. The horses were dispatched, and Morgan took possession of them and put them to his own cannon. At the end of the war, in the month of February, 1871, the Germans in France had, according to the *Augsburg Gazette*, 1587 miles of telegraph, and 91 stations in working order. Their telegraphic system at the end of February, 1871—besides the principal lines centred near Paris, and the circular lines round the capital—embraced St. Quentin, Amiens, Rouen, and Dieppe in the north; Alencon, Le Mans, and Tours in the west; and Orleans, Gien, Auxerre, Montbard, Dole, &c., in the south. Besides this, the telegraphic system in Germany was necessarily extended on the coasts of the Baltic and the North Sea for strategical purposes. Official military intelligence from headquarters was dispatched during the war to 1860 telegraphic stations in North Germany, and to 37 stations on the theatre of war itself.—*Evening Standard*.

ABSURDITIES OF TELEGRAPHIC CENSORSHIP IN FRANCE.

THE Paris correspondent of the *New York Herald* writes as follows of the absurdities of the censorship of messages on French lines:—"Among the despatches which the administration of telegraphs in Paris have thrown into the waste paper basket this year, and refused to deliver because their contents were unintelligible to the gifted creatures employed in the department, is one very touching and ingenious. Here is the text of it: 'Third Epistle of St. John, verses 13 and 14." In opening the Bible, and following these indications, at verse 13 will be found the following words: 'I had many things to write, but I will not with pen and ink write unto thee.' The 14th verse, also, is thus composed: 'But I trust I shall shortly see thee, and we shall speak face to face. Peace be unto thee. Our friends salute thee. Greet the friends by name.' It will thus be seen that by the simple indication in the text of the despatch there is effected a notable economy of words; and perhaps some heart may have ached grievously enough because the absurd fears of official dunces prevented its delivery. Nothing can be more ridiculous, useless, and mischievous than this censorship of telegrams which has now sprung up all over Europe. For it is clear that the least experienced of conspirators would arrange between themselves some cypher which would make their plots appear harmless in the eyes of a telegraph clerk, and none but innocent persons are ever likely to be molested by the censorship. Indeed, it is a favorite amusement of boys who have more money than wit to go and worry a telegraph clerk with a message which rightens him out of his wits, and then, after disturbing all the big wigs of the department, they show that it is only a joke. An acquaintance with the common French name of Bataille is quite a delight to the jesters of this description, for the telegraph clerks cannot maintain that M. Bataille's name and Mlle. Victoire's may not be used in a telegram without a prefix."

Notices to Correspondents.

WE have received from Mr. ST. AUBIN, New South Wales, a paper on Quadruplex Telegraphy, but his arrangement will not work. The key arrangement is needlessly complicated. We would much rather chronicle what has been done than what can be done.

J. J. S.—If you want light literature we can commend you to the *St. Martin's Magazine*. We desire to record experience and pactice, and avoid as much as possible the highly scientific. The elementary is found in abundance in text books. The classes in the telegraphic world are so numerous that it is impossible to satisfy all. We are inundated with matter. Our chief difficulty is to select that which is most useful to the greatest number. At the same time we thank our correspondent for his suggestions.

A TYRO.—No; a sounder is best.

INSPECTOR.—In such a case we would have connected the two circuits together, so as to have made one circuit of half the resistance. You would have spoken through them in spite of the snow.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests to which "THE TELEGRAPHIC JOURNAL" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the EDITOR; business communications to the PUBLISHERS, 10, Paternoster Row, E.C.

WE learn from New York that "the Indians are very thankful for the telegraph poles on the prairie; they formerly had to ride a long distance to find a place to chain a prisoner while they tortured him."

ELECTRIC PILE OF SESQUIOXIDE OF IRON.—This apparatus is contained in a sqnare glass jar. The pile is composed of a prism of charcoal which contains sesquioxide of iron in its pores, and a small rod of amalgamated zinc. The latter passes through the stopper, to the under surface of which is fixed the charcoal. A solution of ammonium chloride is used as the exciting fluid. The reactions are the same as in Léclanché's couple, in which oxide of manganese is used. When the circuit is closed, the chloride of ammonium attacks the zinc, forming a double chloride of zinc and ammonium. The latter, on being set at liberty, decomposes the sesquioxide of iron, carrying off a part of its oxygen and forming free ammonia which disappears by evaporation. This pile ceases to act so long as the circuit remains open. Its durability and force are large. Its electro-motive power is as 12 to 10 of the sulphate of copper battery, and it is thus well adapted for industrial purposes. The inventors are MM. Clamond and Gaiffe, and it is manufactursd by the latter gentleman.